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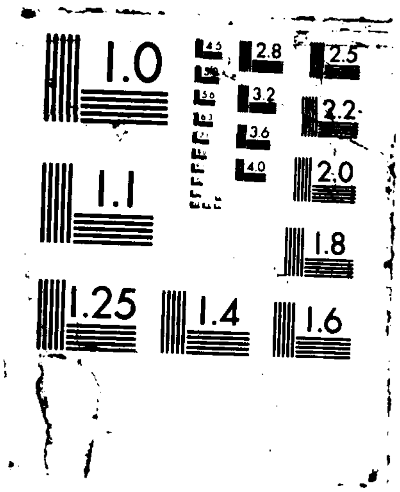
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KALMAN FILTER RESIDUAL EXPERT SYSTEM

THESIS

Jeffrey D. Grimshaw
Captain, USAF

AFIT/GCE/ENG/87D-4

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Wright-Patterson Air Force Base, Ohio

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KALMAN FILTER RESIDUAL EXPERT SYSTEM

THESIS

Presented to the Faculty of the School of Engineering

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Computer Engineering

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Jeffrey D. Grimshaw, B.S.

Captain, USAF

December, 1987

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Acknowledgments

At this time I would like to thank several individuals whose help has been invaluable. My sincere gratitude goes to Major E. Philip Amburn, my thesis advisor, for his insightful guidance and encouragement from the beginning of this project through to its completion. His ability to keep me focused on the "forest" led me to make significant changes in the scope and direction of this research when all I could see were dying trees.

I would also like to convey my appreciation for the outstanding help Dr. Peter S. Maybeck provided as the source of knowledge for my expert system. His optimistic outlook and "can do" attitude were of real encouragement and made my research that much more enjoyable.

Finally I would like to express my thanks to the real source of my encouragement, my Lord and Savior Jesus Christ. I am convinced that without His help, none of this would have been possible.

Jeffrey D. Grimshaw

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Abstract

The Pilot's Associate (PA) Program has been initiated to help mitigate the extensive workload of the fighter pilot. To operate effectively, the PA system must have situation awareness: the status of important on-board and off-board systems. This knowledge is gained through sensor systems. The data from these systems must be "fused" together to present the PA with a coherent picture of the internal (on-board) and external (off-board) states. Although many types of information can be extracted from sensor data, this paper emphasizes those parameters that help determine target track. One common technique for fusing sensor data uses Kalman filters. In a multiple model adaptive filter (MMAF) system, the most appropriate Kalman filter is chosen. This filter provides the "best" estimates of the desired states.

An operating MMAF system continually selects which filter to use as the basis for the state estimates. The overall accuracy of the system is closely related to how well the filters are selected. Previous filter selection techniques have proved useful, but limited. To overcome some of these limitations, an expert system, KREST, was developed so that expert rules could be used to select filters. Although no quantitative estimate of improvement is available, the MMAF expert stated that KREST exhibited a potentially significant improvement over the previously used filter selection techniques.

KALMAN FILTER RESIDUAL EXPERT SYSTEM

I. *Thesis Introduction.*

1.1 Overview.

The Pilot's Associate (PA) Program has been initiated to help mitigate the extensive workload of the fighter pilot. Its purpose is to have a computerized "co-pilot" relieve the pilot of time-consuming tasks so he can concentrate on targets, threats, and terrain. Key to this system is an appreciation of situation awareness: the status of important on-board and off-board systems. This knowledge is gained through sensor systems. The data from these systems must be "fused" together to present the PA with a coherent picture of the internal (on-board) and external (off-board) states. Although many types of information can be extracted from sensor data, this paper will emphasize those parameters that help determine target track. One common technique for fusing sensor data uses Kalman filters. In a multiple model adaptive filter (MMAF) system, the most appropriate Kalman filter is chosen to provide the "best" estimates of the desired states.

1.2 Thesis Statement.

An expert system can be developed, using expert knowledge of Kalman filter characteristics, to select the "best" estimates of the desired state information from a sensor fusion system using such filters.

1.3 Introduction of PA program and need for sensor fusion.

The workload of the fighter pilot has been steadily increasing. Today's pilot is expected to keep track of a myriad of systems and sub-systems, checking them

for anomalies, while simultaneously engaging a target and possibly evading a hostile threat. "The number of tasks he needs to perform far exceeds the number humanly possible" [18, p.1]. This workload will continue to increase as the next generation of fighter aircraft introduce new sensors to which the pilot must respond.

> The information content of the sensor "subsystems" is steadily increasing through innovations such as active-element phased-array radar antennas, focal-plane array infrared sensors, on-board digital terrain and feature storage systems, high-sensitivity with high-angular accuracy anti-radiation sensors, improved navigation sensors and integrated communications systems [5, p.1330].

The problem of information overload can occur when an individual receives more data than he or she can assimilate. When the fighter pilot experiences this problem, he may begin to subconsciously filter out internal or external state information. Internal state information includes the status of his aircraft and weapons. External state information includes the location of threats, targets, and terrain features. By ignoring portions of the data being presented to him, the pilot can concentrate on his prime objective. Unfortunately, some of the information not reaching the pilot may be crucial to the accomplishment of his objective. It may even be crucial to his survival.

Before we proceed, two relevant terms need to be defined: artificial intelligence (AI) and expert system. The definition of AI is nebulous. For this paper, the working definition shall be "those attributes which provide a computer system with the capability to solve problems which are currently better solved by humans." The term "expert system" is defined as "... a computer program that simulates a human expert in a certain field of knowledge" [20, p.1].

To alleviate the workload of future fighter pilots, the Defense Advanced Research Projects Agency (DARPA) has created the Pilot's Associate (PA) Program. The specific purpose of this program is to demonstrate and evaluate the use of AI

and expert systems for increasing the effectiveness of future combat aircraft [5, p.3]. A more thorough definition of PA is provided by Robert G. Eisenhardt:

> Primary functions of the Pilot's Associate are to generate information from available data sources, make assessments and draw conclusions in time domains inaccessible to the pilot, initiate direct action where human response time is limiting, and provide the pilot/crew with selected data/information in a manner that incorporates the pilot in the system in the most efficient manner. Its objective is to ensure that, from the system as a whole, the most tactically effective decision will always be made during combat. [4, p.54]

The kernel task of the PA system is the retrieval of available sensor data and the development of assessments based upon that data. Without this "real world" information, the system can neither suggest nor initiate logical actions. For example, consider a ground-attack mission in progress. The pilot basis all his actions upon his perception of internal (e.g., fuel level and weapon load) and external (e.g., threat aircraft locations and weather conditions) state information. By organizing and examining this data, a system (human or computer) can develop an informed response.

A significant problem with perceiving the external state is the uncertainty associated with the sensed data. Certain sensors are designed to provide various types of information about potential threats. Types of information desired in a next generation tracking/identification system include [23, p.1452]:

1. Track Number.
2. Number of frames coasted.
3. Frequency.
4. Pulse Repetition Interval.
5. Angle of Arrival.
6. Elevation.
7. Range Rate.
8. Lethality (low to high).

9. State Vector ($X, \dot{X}, Y, \dot{Y}, Z, \dot{Z}$).
10. Time to last measurement.
11. Target ID (e.g., MiG-21).
12. Range.
13. Threat Weapon Suite.
14. Current Time. Current Time.

Each sensor system has its own strengths and weaknesses and thus supplies data with varying degrees of precision and accuracy. For instance, a laser rangefinder may provide excellent range data and relatively poor elevation and azimuth data. Relative accuracies of selected fighter aircraft sensors are given in Table 1. By combining data from these various sources, using some type of sensor fusion (SF) process, complementary and competing interpretations can be combined to determine the most likely external state. This fusion process must take into consideration the associated uncertainties in order to intelligently combine the data.

Table 1. Relative Sensor Accuracies.

Sensor	Parameter	Relative Accuracy
Radar	Range	Good
	Range Rate	Good
	Azimuth	Fair
	Elevation	Poor
ESM	Azimuth	Poor
	Target ID	Good
	PRI, RF	Good
IR	Azimuth	Good
	Elevation	Good
Threat Warning	Missile Approach Warning	Good
IFF	Friend, Foe, Neutral	Good
	Range	Good
	Height	Good

Source: [23, p.1452]

There are actually two types of uncertainty that the PA will need to consider. First is the uncertainty associated with the data. This includes both accuracy and precision. This is the type of uncertainty that will be addressed in this paper. The second uncertainty deals with the logic used to combine the sensed information. For instance, assume the radar has identified a target with a certain amount of accuracy and precision. Also assume the infrared search track (IRST) system has also identified a target at a position close to that identified by the radar. The system may choose to assume these "targets" are actually a single target or that there are really two targets flying in proximity to one another. The system should provide the confidence level or measure of certainty associated with this conclusion.

The data from the individual sensors tend to be very noisy. One technique that has been used extensively in "cleaning up" the data involves Kalman filters. (See Section 3.1 for more information on Kalman filters.) In this application, a Kalman filter may be thought of as a black box whose input is the data from one or more sensors and whose output is one or more desired parameters. For instance, the input may be the sensed X-direction position while the output is the velocity in that same direction. The filter uses feedback and weighting functions to determine the "best" estimate by comparing the previous estimate with newly sensed data. For example, consider the case where the X-direction position datum was 2000.00 km and the resulting X-direction velocity estimate is 360 km/hr. If a new datum is taken every second, the next value should be 2000.10. If the actual datum is 2000.08 then the velocity estimate needs to be changed and/or the datum is incorrect. The weighting functions can be tuned to emphasize the actual data or the estimate of what that data "should" have been. If the actual data is emphasized too much, the output will become noisy just like the input. However, if the estimate of the data is emphasized too much, the system will not respond quickly enough to changes being indicated by the sensors.

Sensor data fusion can take place at two points within the SF portion of the PA. The fusion can occur after the data from the sensors have been "cleaned up" by the Kalman filters, or it can occur within the set of filters. Research is being conducted in both of these areas. Much of the current work within the AI community in the field of reasoning under uncertainty (RUU) has attempted to merge the data after the filtering process since the Kalman filters algorithmically smooth the data. Hence, the RUU programs can use data with much less inherent noise. Some of the previous research in this field will be addressed in Chapter 2. Work being conducted by Kalman filter experts has emphasized fusion within the filtering process. This includes developing advanced filter models and improved filter selection techniques.

1.4 Expert System Justification

Donald Waterman has outlined several criteria that he believes a project must meet in order to show that an expert system is necessary [22, p.129]. These items are listed below:

- The task must not require common sense. The Kalman filter expert system does not.
- The task must require cognitive and not physical skills. No physical skills were required in this problem domain.
- Genuine experts must exist. A Kalman filter expert was selected: Dr. Peter Maybeck of the Air Force Institute of Technology, Wright-Patterson AFB, OH. In addition to having several published papers in this field, Dr. Maybeck has written several books on the subject [10] [11].
- Experts must agree on the solutions. Since only one expert was used, this was not a problem. A numeric evaluation of the expert system results would indicate how well the expert did at selecting Kalman filters, however it was decided that a numeric evaluation would be beyond the scope of this research.

- The expert must be able to articulate his reasoning methods. The expert was confident that he could select filters better than the original system, but it was not clear what the basis for this selection would be. Much of this research centered on identifying the information needed by the expert to make the decisions.

- The task must not be too difficult nor poorly understood. The final goal, selecting a filter, was easily understood, however the actual selection process was not. By presenting the expert with information he felt was necessary, both the expert and the knowledge engineer gained a better understanding of the filter selection process.

Donald Waterman also identified criteria to justify the development of an expert system [22, p.130]. Several apply in this case:

- Is human expertise scarce? While the overall operation of multiple Kalman filter systems is well understood, the limitations associated with filter models is not as generally understood.

- Is the expertise needed at many locations? Yes, since this type of system would eventually be executing in real-time on-board a fighter aircraft.

- Is the expertise needed in a hostile environment? Yes, for the reason listed above.

1.5 Scope of Research

The purpose of this research was to investigate the use of an AI technique to help improve the sensor fusion capability within the Kalman filter system. Specifically, this required that an expert system be developed using expert knowledge of Kalman filter characteristics, to select the "best" estimates of desired parameters.

Some type of simulated multiple model Kalman filter program was needed to develop the expert system. Ideally, this program should have simulated the fusion of

data from fighter aircraft avionics. Since this type of Kalman filter software was not available, we chose to build an expert system to evaluate the filter selection process of an existing Kalman filter program which simulated five discrete filters. These filters did not simulate sensor fusion. However, according to the expert [14], improvements resulting from the use of the expert system should be extendable to filters combining and contrasting data from multiple sensors. This results because the expert system does not reason over the input to the Kalman filters (i.e., data from one or more sensors), but on the output from the filters (i.e., the state estimates, residual values, etc.). An expert system could be designed to be oblivious to which sensor or set of sensors provides data for each filter. However, this type of information may be useful in enhancing system performance.

After identifying the Kalman filter simulation program to be used, three major tasks remained, constituting the bulk of the research. These tasks were: to determine from a Kalman filter expert what basis he uses for selecting the best filter, to acquire and encode this knowledge in an expert system, and to compare the performance of that expert system with the current filter selection process.

5

II. Historical Development

Before delving into historical approaches to reasoning under uncertainty and Kalman filter developments, an appreciation for the mission of the Pilot's Associate will be given. By reviewing the various modules of the PA and how they interrelate, the reader can gain an appreciation for the types of information required from the SF portion of the system. Following this discussion, some of the past and present techniques of reasoning under uncertainty and Kalman filter usage will be presented.

2.1 Mission and background of the PA system.

The concept of the Pilot's Associate needs to be partitioned in order to keep it manageable. There have been several attempts at identifying the major components of the PA system. Kenneth Maxwell and James Davis have identified three major components: the Pilot/AI Interface, the AI System, and the AI/Vehicle Interface [15, p.91]. They further divide the AI System into Knowledge Bases and Control Structures [15, p.91]. Dr. Teichgraeber also identifies three components: Situation Awareness, Tactics Planning, and Internal Systems Monitoring [20, p.1]. A more elaborate division of PA components is provided by Major Frankovich and Messrs. Pedersen and Bernsteen. They identify three possible divisions of avionics tasks as part of the PA system. Their minimum configuration has four components: Flight Systems, Offensive Systems, Defensive Systems, and Status and Configuration [5, p.1332]. While there may be merits to each of these partitionings, a clearer division is provided by Robert Eisenhardt. He identifies the following five major components: Pilot/Vehicle Interface, Mission Manager, Tactical Manager, Situation Awareness Manager, and System Status Manager [4, p.56]. In this organization, the SA Manager is responsible for controlling the sensor systems and fusing the sensed data. These responsibilities are in addition to that of assigning state vectors (e.g., position and velocity) and providing target classification information about each threat [4, p.57].

The functional diagram developed by the AFWAL Pilot's Associate Program is very similar to that identified by Mr. Eisenhardt, except that the PA Program version provides a separate manager for controlling and integrating the sensor resources. This manager will be referred to as the Sensor Fusion (SF) Manager. Although the SF Manager is not strictly part of the PA system, its function is key to that system's mission. As with any computer program, the performance of the PA system can only be as good as the data being entered in. This partioning, shown in Figure 1, will be referenced throughout the remainder of this paper.

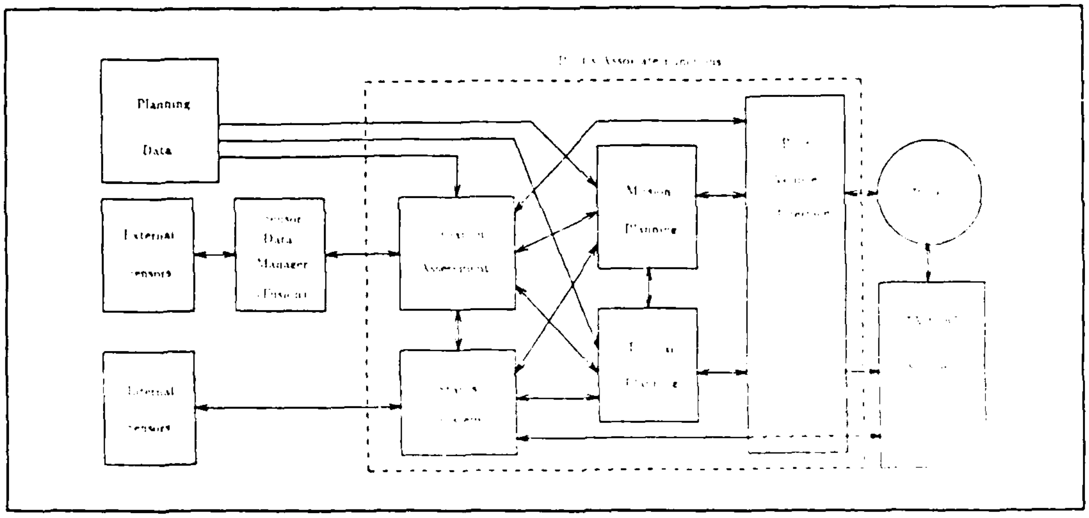


Figure 1. Pilot's Associate Block Diagram
[1, p.9]

2.1.1 Pilot/Vehicle Interface. The Pilot/Vehicle Interface (PVI) will have a significant impact on how the whole PA system is accepted by pilots. In the past, new weapon/sensor systems have required a pilot to keep track of more data while he simultaneously attempts to engage a primary target. As the pilot becomes saturated with information, he unconsciously ignores certain portions of that information. The

PVI must present information to the pilot in a quantity and mode that will allow him to evaluate the situation and select appropriate responses in a minimal amount of time, without becoming saturated [15, p.90].

The quantity attribute of presented information is related to the concept of Miller's Magic Number Seven [8]. This limit refers to the number of simultaneous tasks which an individual can keep track. As the pilot becomes busy (such as when attacking a target), the PVI should restrain from overwhelming him with data. As the pilot's workload becomes lighter, more data can be presented to him without overwhelming his capabilities. The mode attribute of the PVI is another area of investigation [15, p.91]. Several modes are available, including cathode ray tube, heads-up display, control panel lights, buzzers, synthetic voice, etc. Human factors engineers, using techniques developed in cognitive psychology, will need to identify the most effective means of conveying information to the pilot.

2.1.2 Mission Manager. The Mission Manager component of the PA is responsible for the navigation and route planning functions. This component must identify a flight corridor which considers

> ... tactical doctrine, aircraft capability and loadout (fuel, weapons, avionics), mission objective, terrain, known ground threat locations, probable threat areas, probable air threat, time windows coordinating the mission, and target and alternative target locations [5, p.1332].

This manager is also responsible for responding to changes in the mission. If the pilot is redirected to an alternate target or if he must discontinue his mission due to malfunction/damage, the Mission Manager must provide the pilot with his new options [1, p.12].

2.1.3 Tactical Manager The Tactical Manager is responsible for combat engagement options and weapon selection. This function shall "... recommend to the pilot an 'intelligent' course of action (e.g., tactics, trajectory, weapons choice, coun-

termeasures) to deal with the current combat situation" [1, p.11]. These tasks are fairly well understood and have been researched, in part, by Captain Sobota. Her thesis identified the process used by F-16C aircraft in the air-to-ground weapons delivery mode [18, p.9]. The main thrust of her research was to develop a mechanism whereby a pilot could "tell" the computer the desired sequence for weapon selection. This would allow the PA to know not only the proper sequence (which can often be varied), but also the sequence that the pilot preferred. A complete Tactical Manager would also include engagement options. This system would provide options to ignore, evade, or attack a target, and, if necessary, a preference in how the target is to be engaged [1, p.10].

2.1.4 System Status Manager. The System Status (SS) Manager is responsible for monitoring all on-board systems so as to identify, diagnose, and verify systems that are malfunctioning [1, p.11]. More specifically, the "... SS function shall monitor the status of on-board expendable resources (e.g., fuel, weapons, etc.) and external, cooperative resources (e.g., wingmen, AWACS, C3I functions)" [1, p.11]. If important, this information may be sent to other PA Managers. Information regarding emergency situations would be sent to the Mission and Tactical Managers as well as directly to the pilot through the pilot/vehicle interface. The SS will also provide a suggested course of action to the pilot to help minimize the severity of the malfunction [1, p.11].

2.1.5 Situation Assessment Manager. This manager is responsible for determining the threat potential and intent assessment of enemy weapons and for assessing the external environment conditions [1, p.10]. In other words, the Situation Assessment (SA) Manager must "... provide the pilot and other major processors with as complete and current a description (model) of the current external world as possible" [1, p.57].

Information concerning the state of the "real" world is sent from the SA Man-

ager to the Mission and Tactical Managers. Thus, mission and tactical planning can be performed in response to the changing threat. If a situation arises requiring the notification of the pilot, the necessary information is sent directly to the PVI for display [4, p.56]. If the notification requires an immediate response, the Tactical Manager should be able to provide (and, in emergency situations, possibly automatically execute) a suggested course of action.

2.1.6 Sensor Fusion Manager. The plethora of raw data might overwhelm the SA Manager. In order to extract higher level information from this data, a Sensor Fusion Manager [23, p.1451] has been suggested. Data entering this module would be sourced from the identify friend/foe system (IFF), radar, infrared search track (IRST), electronic support measures (ESM), inertial navigation system (INS), and communication links [4, p.58]. This module fuses the measurements from these sources "...to formulate a 'single picture' of the surveillance volume 'seen' periodically" [23, p.1451]. This fused data may be presented to the pilot, used to update fire control data, and/or sent to the SA Manager. The Sensor Fusion Manager also uses this data, primarily for sensor allocation and management [4, p.57].

The performance of the other managers is dependent, at least in part, on the SF Manager. Thus, any improvements in the performance of the SF Manager should result in improved overall performance of the PA system. Because of this, the SF Manager was selected as the basis for research in this paper. The remainder of Chapter 2 will address previous efforts to improve the sensor fusion process.

2.2 Previous sensor fusion research.

One of the primary reasons for having sensors on-board tactical aircraft is to provide the pilot with an improved sense of situational awareness. This awareness falls into several categories. These categories include: navigation ("Where am I?"), system status ("Is everything okay?"), target detection ("Is anyone out there?"),

target tracking ("Where are they?"), target identification ("Who are they?"), and threat assessment ("Who's my biggest threat?"). To get this information, sensor data must be fused and interpreted.

The problem of sensor fusion stems from the fact that there is no ideal sensor providing totally accurate and precise data over all sensible domains. Since data from multiple practical sensors may be repetitious, complementary, or conflicting, techniques have been developed to synergistically merge the information to provide the most realistic view of the "real" world.

Three categories of techniques have been developed to address the fusion problem. The first uses AI techniques that were developed to facilitate reasoning under uncertainty. This technique uses processed data that may have been refined by Kalman filters. The second technique is a hybrid one that attempts to address both the post-filter RUU techniques as well as the processing of the raw data that occurs within the filters. The last technique concentrates on the processes that go on within the Kalman filter system, using expert knowledge to make improvements in performance.

2.2.1 Reasoning with uncertainty techniques. A fairly comprehensive review of current work in handling uncertainty in expert systems has been written by P.P. Bonissone [3]. He concludes that there exists two basic approaches to representing uncertainty: numerical and symbolic characterizations [3, p.2].

2.2.1.1 Numeric Approaches. Numerical approaches are characterized by values represented by a single number or an interval. This method is most useful when the relationships and independence between variables can be fully described. Since specific numbers are involved, a calculus is usually developed for combining and separating values of interest. The use of one type of numerical characterization, Evidential Reasoning, in the domain of sensor fusion has been investigated by Thomas Garvey.

Evidential Reasoning. Work by Thomas Garvey, et al., has focused on the use of "evidential propositional calculus" [6, p.319] for the purpose of electromagnetic signal identification. This technique is known as Evidential Reasoning and considers both reasons for supporting and negating certain conclusions. This method is based primarily upon the Dempster-Shafer theory [3, p.9]. The representation for each proposition has a lower and upper value. The lower value, denoted as s(a), represents the support of that proposition. The upper value, denoted as p(a), represents the plausibility of the proposition. "Support may be interpreted as the total positive effect a body of evidence has on a proposition, while plausibility represents the total extent to which a body of evidence fails to refute a proposition" [6, p.320]. Using this notation, a proposition A may be written as A[s(A),p(A)]. The following examples further explain the use of this notation:

```
A [ 0, 1] : No knowledge at all about A.
A [ 0, 0] : A is false.
A [ 1, 1] : A is true.
A [.2, 1] : Evidence partially supports A.
A [ 0,.8] : Evidence partially supports \={A}.
A [.2,.8] : The probability that A is true is
               between 0.2 and 0.8.
A [.5,.5] : The probability that A is true is
               exactly 0.5.
```

The use of this notation provides a continuum of representation from the one extreme of Boolean logic (which allows only true or false conditions) to the other extreme of Bayesian logic (which allows for uncertainty). Given this notation and two statements A[s(A),p(A)] and B[s(B),p(B)], three basic logical functions are defined as [3, p.9]:

```
Intersection: C = AND(A,B)
              where s(C) = max(0, s(A)+s(B)-1)
              and   p(C) = min(p(A), p(B))

Union :       C = OR(A,B)
```

```
               where s(C) = max(s(A), s(B))
               and   p(C) = min(1, p(A)+p(B))

Negation :     C = NOT(A)
               where s(C) = 1 - p(A)
               and   p(C) = 1 - s(A)
```

This technique was used to fuse data from simulated passive electronic support measures (ESM) sensors [6, p.322]. These sensors would identify in which radio frequency (RF) and pulse width (PW) ranges the threat radars were operating. This example could be viewed as the fusion of threat identification information from an RF sensor and a PW sensor. The system is provided with a knowledge base of unique RF – PW signatures for the known threats. When a simulated threat radar signal is received, the RF and PW characteristics of the signal are compared with those in the database resulting in pairs of RF and PW support and plausibility values. By combining the likelihoods that the threat has an RF like that of Threat X and a PW like that of Threat X, a unified set of support and plausibility values may be assigned. By repeating this for each threat in the knowledge base, a best estimate for the threat identification could be reached.

This technique may yield useful results when identifying a target from a table of targets. However, the problem of target tracking does not lend itself to this type of selection process. Since a target could be at any place within a range of locations, a single datum would be insufficient for generating a support – plausibility pair.

2.2.1.2 Symbolic Approaches. The symbolic approach lends itself to those applications where the information provided tends to be subjective or have imprecise relationships between variables [3, p.2]. The basic premise of each of these representations is to define variables in such a way that they can be combined together in a logical and intuitive manner. The use of a symbolic characterization, specifically the Theory of Endorsements, has been considered by the Threat Expert Analysis System (TEAS) [19] program and by Shafer [17].

Threat Expert Analysis System. The Treat Expert Analysis System (TEAS) program is also investigating the use of sensor fusion in the fighter aircraft domain. For this program "...the desired results are recommended solutions for threat response and threat prioritization in real time" [19, p.1]. As the author rightly points out, "In the threat assessment and reaction domain, as in any domain which includes aspects of the real world, uncertainty plays a major role. Virtually any piece of information is uncertain to some degree" [19, p.2]. More specifically, the pilot's uncertainty falls into one of nine categories:

Direct Ignorance: The knowledge of a problem with no knowledge of the details. For instance, a pilot may know there is a threat in the environment, but have no information about its location.

Indirect Ignorance: The lack of knowledge that a problem even exists.

Partial Knowledge: The knowledge of some, but not all, of the details surrounding a specific problem.

Insufficient Precision: The resolution of the sensed data is not adequate to make some determination. For instance, range information from a radar may be so coarse that two targets flying in close formation cannot be separated.

Inaccurate Sensors: Sensors that provide biased or wrong information. As an example, an INS will tend to drift producing results that are increasingly biased.

Unreliable Sensors: Sensors that do not always operate correctly. Since any sensor can malfunction, the results from that sensor should be viewed stochastically and not deterministically.

Countermeasures: All types of active and passive means used by an opponent to deny, degrade, or deceive a sensor.

Conflicting Information: Inconsistent information that is presented by two or more sensors. This can occur when one or more of the sensors suffers from one of the other types of sensor uncertainty. For instance, if the radar is being jammed through the use of decoys, the radar's returns will probably conflict with those of the IRST.

Old Information: The time dependence of data and the fact that data from various sources is probably not sensed at the exact same time. This is especially true in the rapidly changing fighter aircraft domain [19, p.3].

In developing a framework for solving the problems of situation assessment and reaction, the authors have concluded that symbolic methods of uncertainty

representation should be used. The purpose of the situation assessment function is to develop as many logical interpretations of the sensed data as possible, giving each one some type of certainty or likelihood value. The function of reaction is to determine the best course of action that will "handle" as many problems as possible. "Often, what is sought is not necessarily a course of action which 'wins' in each interpretation, but rather one which does not 'lose' in any interpretation" [19, p.6].

Whiteboard Architecture. The use of symbolic reasoning in developing a framework for sensor fusion has also been researched by Steven Shafer, et al. [17], this time in the development of an intelligent mobile robot. Their work was done at the Carnegie-Mellon University Vision Lab using a mobile robot vehicle called NAVLAB. The result has been the development of a "whiteboard" architecture having distributed concurrent software modules and a database/communication system for fusing sensed data [17, p.1]. A "whiteboard" architecture is defined as being "...heterarchical like a blackboard, but each module runs in parallel with the module programmer controlling synchronization and data retrieval requests as best suited for each module" [17, p.5]. This architecture readily lends itself to a parallel implementation.

The purpose of Shafer's research is to develop an autonomously navigating vehicle. Sensors used by the system include mono and stereo TV cameras, an ERIM laser rangefinder, and sonar equipment. Each type of sensor has a dedicated SUN workstation that is linked to the other SUNs using an Ethernet connection. A fourth SUN, also connected via the Ethernet, is used to maintain the local map database and for planning the activities of the system.

The NAVLAB system reportedly uses three types of sensor fusion. These are competitive, complementary, and independent. Competitive data either reinforce or conflict during the fusion process. This type of fusion is often used when the sensors produce the same type of data. For example, two sonar sensors may locate the same

obstacle at slightly different positions. Complementary data is returned when the sensors have differing characteristics (e.g., field of view, resolution, range, etc.). In this case, sensors are used individually to enhance their strengths while attempting to cover their weaknesses. As an example, the TV cameras may be used to coarsely locate an obstacle following which the laser rangefinder is used to precisely determine the obstacles position. Lastly, independent data is derived from a single sensor in a kind of "non-fusion" mode in which a single sensor is used to perform a specific task [17, p.18]. For example, when looking directly into a bright sunset, only one sensor (possibly the sonar equipment) may be able to detect obstacles.

When fusing data, NAVLAB primarily uses the complementary technique. As the system attempts to navigate through a portion of road by finding an obstacle-free path, specific sensors are used in a basically programmed, independent manner. When these sensors "need help" due to limitations in coverage, etc., other sensors are activated to provide the missing data. While this complementary type of data fusion may work well in a relatively slow-moving, simplistic "threat" environment, its use may not be indicated in the dynamic and complex environment of the modern fighter aircraft. In this more demanding domain where sensor returns may often be competitive in nature, sensor fusion will often be required at the signal-level. Thus, the problem is not simply connecting data, but one of fusing them together.

While symbolic reasoning may be appropriate in solving the situation assessment and reaction problems, this technique may not work for the sensor fusion problem. The use of symbolic reasoning is intuitively closer to how humans think through problems as opposed to the numerically-based sensor domain. As such, symbolic representations are indicated on the "pilot-side" of the Pilot's Associate system. This includes the PVI, Mission Planner, Tactical Planner, and possibly even the Situation Assessment, modules. The "sensor side" of the system, including processing of the signal within the sensor as well as the Sensor Fusion module, lends itself to a numeric representation.

2.2.2 Composite Approach. Ronald Yannone has chosen to consider both the numeric sensor data processing and the symbolic expert reasoning processing within the same system. As he states:

> It is anticipated that a high percentage of the fusion function will be computational and that some "expert" reasoning might be used. The fusion expert would bring to bear the following features in order to assign a quality factor to each composite track file entry: mission information, geography, potential "intent" of the target, probability of detection and false alarm, a priori information regarding anticipated threats, the threat class, kinematic state vector, and sensor measurement accuracies [23, p.1454].

The suggested framework for implementing this system is shown in Figure 2. The sensor data are "cleaned up" using dedicated signal processors. From there, the signals are sent to track processors so that threat track files can be developed. The common reference alignment block performs the necessary temporal and spatial shifts of the track files from the various sensors. Following this, the tracks are merged together in the intertrack file association module. The fusion that occurs here is performed by one or more Kalman filters. The resulting composite track file is then sent to the Situation Assessment/Response Management module for evaluation. This module performs a function similar to that of the Situation Assessment and Tactical Mission Planner modules of the Pilot's Associate (see Figure 1). At this point, a rule-based expert system utilizes symbolic knowledge to reason over the new information, update the database, and suggest/initiate intelligent responses. This is similar to the Hybrid Multisensor Fusion Data Flow Model developed by Julius Reiner [16, p.1449].

The process graphically presented in Figure 2 clearly separates the sensor fusion process which occurs on the "sensor-side" from the situation assessment function which is performed on the "human-side" after the composite track has been created. The validity of the results produced by the situation assessment expert system is strongly related to the quality (accuracy, precision, etc.) of the composite

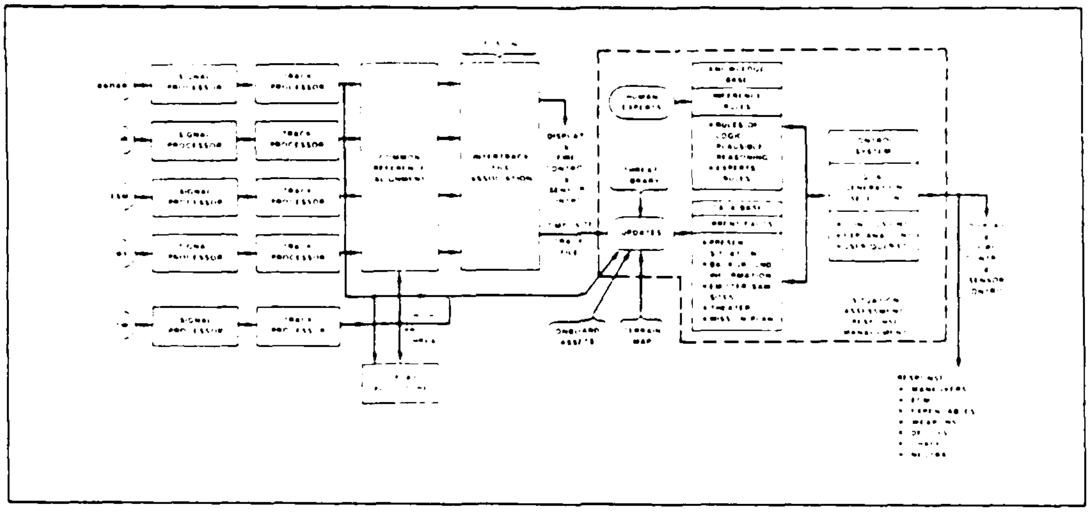


Figure 2. Multisensor System Block Diagram
[23, p.1455].

track file. This, in turn, is dependent upon how the tracks are being fused together. What criteria is used to fuse the tracks? Is any significant information being lost in this fusion process? The Air Force Wright Aeronautical Laboratories (AFWAL) is researching ways to intelligently control the data fusion process that occurs within a Kalman filter system. Part of this work is outlined in the following section.

2.2.3 Multiple Kalman Filter Approach. Research is currently being sponsored by AFWAL to investigate the use of an expert system in choosing between combinations of navigation sensors that pass through Kalman filters [2, p.1]. This project, known as the Adaptive Tactical Navigation (ATN) system, is provided with expert knowledge about the quality, availability, and desirability of using various sources of position and/or velocity information. The purpose of the ATN system is to "...combine Artificial Intelligence (AI) techniques and advanced navigation algorithms to effectively manage the multisensor navigation suites of 1990's tactical

aircraft" [2, p.1].

The navigator portion of the ATN system receives data from various sensors:

1. INS (Inertial Navigation System).
2. GPS (Global Positioning System).
3. Barometric Altimeter.
4. TERCOM (Terrain Contour Matching).
5. SITAN (Sandia Inertial Terrain Aided Navigation).
6. JTIDS Datalink (Joint Tactical Information Distribution System).

The ATN uses a Basic Navigation System (BNS) that has a set of four Kalman filters to track the performance of various combinations of sensors. This is shown graphically in Figure 3. (Note: The INS/Barometric Altimeter combination is not, strictly speaking, considered a Kalman filter [2, p.4].) The resulting states, S0 through S10, provide "best-guesses" of the current kinematic state of the aircraft. In conjunction with the BNS is the Expert Navigation System (ENS) which monitors the operation of the BNS to help identify any problems or special situations that may arise.

Once the ENS determines that the currently selected sensor combination is providing inaccurate results, it determines the location of the fault [2, p.5]. Once the fault has been located, the ENS will determine if the navigational data should be taken from a different sensor combination and, if so, which one. To perform this function the ENS is given a priori knowledge of the quality of various sensor combinations. This knowledge is represented in Table 2. As an example, if the primary mode (S0) becomes non-operational, the first backup modes to be considered are S1 and S2 depending upon where the fault was located.

The sensor fusion technique selected by AFWAL attempts to enhance the function of Kalman filters by using expert knowledge.

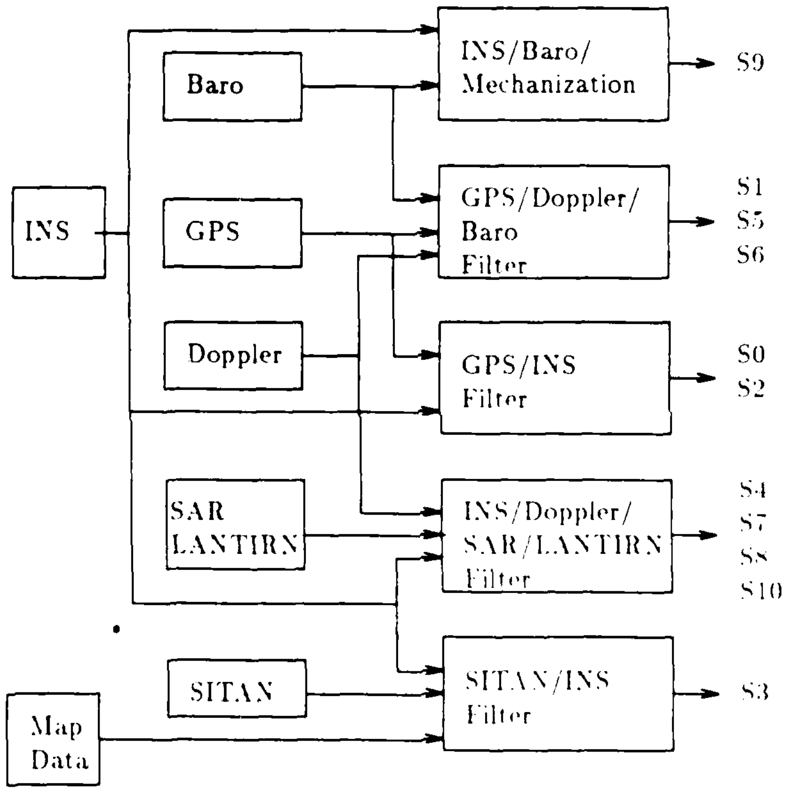


Figure 3. Basic Navigation Architecture
[2, p.4].

Table 2. ATN Navigation Modes.

Symbol	Sensors
S0	INS, GPS4
S1	GPS4
S2	INS, GPS3
S3	INS, SITAN
S4	INS, Doppler, SAR/LANTIRN
S5	GPS3, Doppler, Baro
S6	GPS3, Baro
S7	INS, Doppler
S8	INS, SAR/LANTIRN
S9	INS
S10	Doppler, LANTIRN

Source: [2, p.4]

> The basic philosophy of the Expert Navigator is to integrate the expertise and mission perspective of flight crews into the navigation process, along with the traditional algorithm-based techniques for managing the aircraft navigation suite. ...Techniques developed in AI are appropriate to integrate this human perspective and knowledge gained through experience into the knowledge base of the Expert Navigator. It is recognized, however, that algorithmic approaches such as Kalman filtering provide information needed to form a logical basis for subsequent action on the part of the flight crew. Consequently, these algorithmic tools are <u>integrated into</u> but <u>not supplanted</u> by the overall AI framework [7, p.3-1].

As the BNS updates navigational information, the ENS checks for anomalies (e.g., sudden changes in location/velocity estimates or large error signals from the Kalman filter). Once an estimate becomes "significantly poor," the ATN system uses the ENS to identify the source of the problem. If the problem is believed to be with either the external source of the data or with the sensor of that data, the system can choose a different navigation mode. This technique makes sense in the case of navigational data. The normally highly accurate GPS updates provide sufficient information. Only when this source cannot be received (e.g., sensor failure, electronic countermeasures, etc.) should the system select a different navigational reference.

Using a pre-sorted (i.e., primary, secondary, etc.) Kalman filter selection criteria would not be appropriate for target tracking. No sensor stands out in the target tracking problem as the GPS source did in the navigational problem. In addition, target tracking is often done with multiple Kalman filters, each tuned for a different target trajectory (e.g., benign, harsh vertical maneuver, etc.) Some mechanism must be used to not only select between Kalman filters receiving data from different sensors, but also select between filters employing differing target trajectory models. Since target trajectories can change rapidly in the air-to-air combat environment, this filter selection process must also proceed expeditiously.

The remainder of this paper will present a more thorough overview of Kalman filters and the development of a new Kalman filter selection process. This selection process is a knowledge-based system that uses rules formulated by a Kalman filter expert.

III. Kalman Filter Residual Analysis.

3.1 Kalman Filter Overview.

A Kalman filter may be thought of as a recursive data processing algorithm. This filter is recursive in that it uses a feedback loop to compare its output, a state estimate, with the next input measurement [10, p.217]. A diagram of a simple Kalman filter is shown in Figure 4.

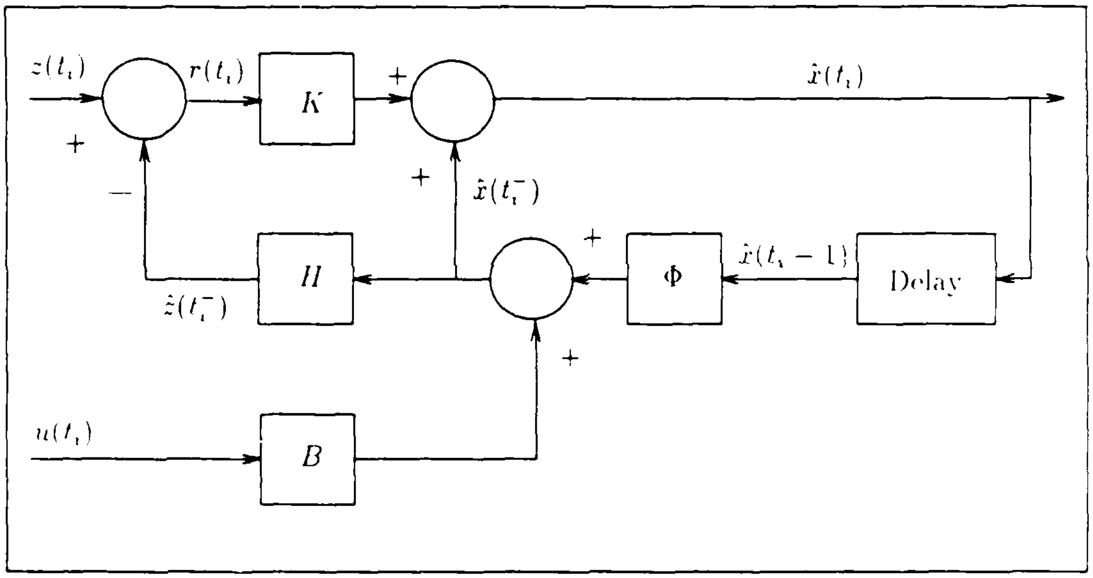


Figure 4. Basic Kalman filter design
[10, p.217].

The values K, H, B and Φ are matrices that define the characteristics of the filter. The K matrix defines the filter's internal model. The H matrix defines the measurement model characteristics. The B and Φ matrices identify the dynamics model parameters. The process of adjusting the K matrix so the filter responds to certain changes in the input is known as tuning. The measurement $z(t_i)$ is the input

at time t_i. The value $\hat{z}(t_i^-)$ is the filter's best prediction of the actual measurement $z(t_i)$. This prediction is computed by the filter at time t_i^-. The difference between the actual measurement and the predicted measurement is known as the residual and is identified as $r(t_i)$. The residual "...is then passed through an optimal weighting matrix K, and used to correct $\hat{x}(t_i^-)$, the best prediction of the state at time instant t_i before the measurement is taken at time t_i." [13]. For a full explanation of the filter and associated notation, see [10] and [11]. The residual may be likened to an error signal, although strictly it is not since the original measurement, $z(t_i)$, has uncertainty associated with it.

The magnitudes of the residuals are related to how well the matrices model the characteristics of events in the real-world system. For example, two filters could be developed to track a target from radar data. One filter could be tuned for targets moving at constant velocity while the other could be tuned for targets characterized by constant acceleration. If the target did indeed travel at constant acceleration, the "goodness" of the corresponding filter should be indicated by the relatively low residuals during its updates. The filter having the less appropriate set of assumptions (i.e., that the target would have a constant velocity) is expected to have larger residual values.

Filters could also be developed to combine data from different types of sensors, each weighing such factors as individual sensor reliability and precision and the believed accuracy of the filter model. While sets of single-sensor filters could be developed, the standard implementation is to develop one set of filters having access to all related sensor data [13]. Allowing more than one sensor access to the Kalman filters provides a mechanism for sensor fusion.

Kalman filter residuals also provide the added benefit of indicating when a sensor has begun producing poor data.

> When all measuring devices are operating correctly, the difference signals entering the optimal gain matrix...[i.e., residuals]...should be white

> sequences with zero mean and predictable covariance (or standard deviation). If any of the residuals consistently differ from this description, a measuring device failure can be detected and often isolated to the exact device that is at fault [12, p.39].

The actual cause of the problem may be due to a sensor malfunction, jamming, or some other change in the system of interest or its environment that invalidates a model which had previously been adequate.

3.2 Current filter selection process.

In a multiple-filter system, each filter develops its own best estimate of the desired variables (e.g., target location and velocity) as well as a residual associated with that estimate. An example of this type of system is shown in Figure 5. The final state estimate provided by the multiple-filter system is based upon a weighted addition of the individual filter estimates. This weighting function is actually a conditional probability derived from a Bayesian estimation of the residuals [11, Sec10]. This Bayesian estimation is the conditional probability that the parameter value produced by each filter is in fact the best estimate available, based upon that filter's residual values up to that time. This value, known as the residual's hypothesis conditional probability, shall be referred to as the residual's probability. The sum of these probabilities across all filters is one. The final weighted estimate is referred to as the Bayesian estimate.

An alternative to weighting the multiple Kalman filter estimates is to select the estimate from the filter with the largest residual probability. This technique is known as maximum a posteriori (MAP) state estimation [9, p.20]. As an example, assume filters A and B have residual probabilities of 0.6 and 0.4, respectively. Instead of computing a weighted average of the filter state estimates ($0.6\hat{x}_A + 0.4\hat{x}_B$), just select filter A's estimate. A Monte Carlo simulation comparison of the Bayesian and MAP estimates showed that, at least for the Kalman filter models and target trajectories used, the techniques resulted in very similar performance [9, p.83]. The

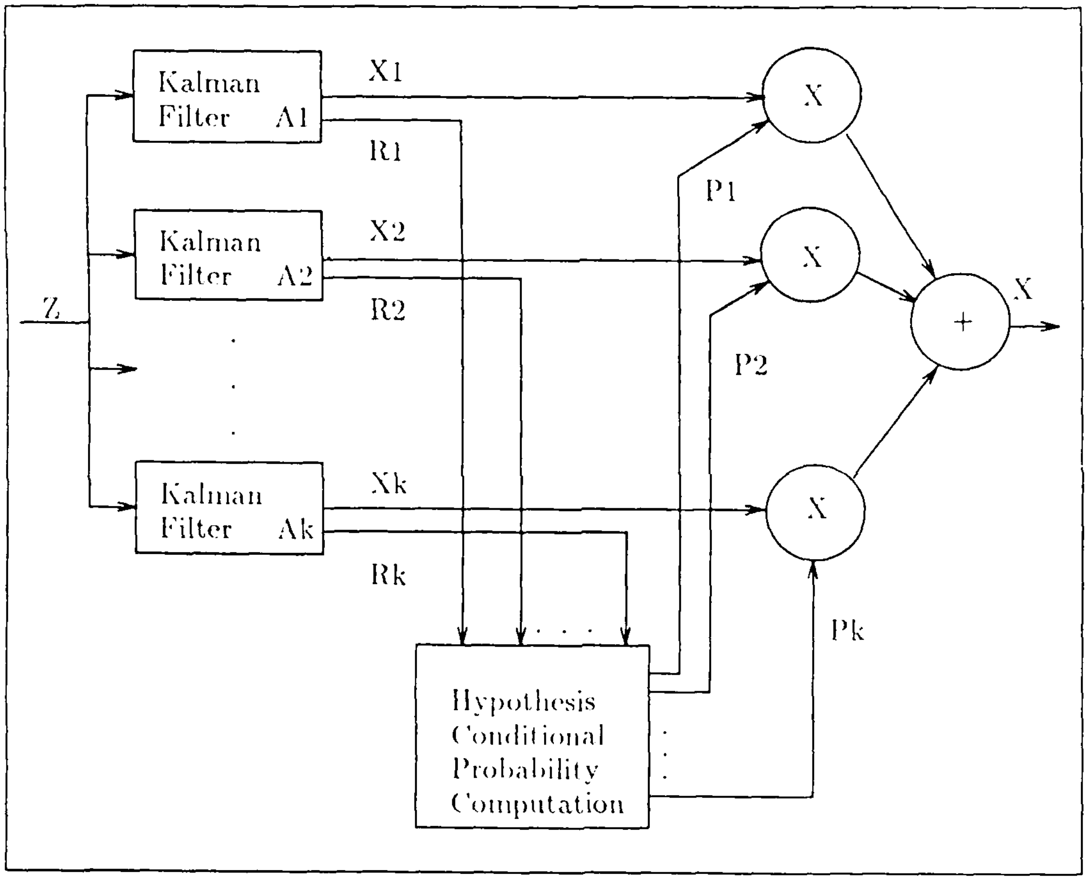


Figure 5. Multiple model filtering algorithm
[11, p.123].

MAP estimate technique will be the one considered throughout the remainder of this report.

3.3 *Problems with current selection process.*

Dr. Maybeck [14] has identified two problems that can occur when selecting the best filter to use in a multiple-filter system. (The "better" and "best" filters are those deemed that way by the expert.) The first problem he identified was a tendency for certain filters to "hold on" to the system longer than they should. Because of this, there can be a delay in switching to a better filter. The second problem he identified could occur when a new filter needed to be selected. Under certain situations, the filter with the new highest residual probability may not be the correct one to choose. Dr. Maybeck stated that he and other filter designers could do a better job at selecting filters than the original system did.

As an example, consider a Kalman filter system having three filters designed to provide location information about a target. Assume that filter A has a high-precision, narrow-view model (this filter should be used when the target is not maneuvering), filter B has a medium-precision, medium-view model (this filter should be used when the target is maneuvering moderately), and filter C has a low-precision, wide-view model (this filter should be used when the target is harshly maneuvering). The target has been performing a high-g maneuver so the system has been selecting the state estimate from filter C. As the target ceases accelerating, the residual probability of filter C begins to decrease while those of filters A and B increase. Since the target has stopped accelerating, the best filter to select would be filter A. However, the actual system will wait for the residual probability of filter B to rise above that of filter C. At that point the system will select filter B. Eventually the residual probability of filter A will surpass that of filter B, leading to the final selection of filter A. This delay in selecting the best filter results in sub-optimal performance.

3.4 Proposed filter selection criteria.

To arrive at a solution, an expert must use information relative to the problem. The information provided by Kalman filters (i.e., the raw residual data) is not in an appropriate format for an expert to select a filter. An example of raw residual data is shown in Figure 6. Each filter produces X and Y residuals which correspond to the X and Y target location estimates developed by the filters. (X and Y refer here to the target's apparent azimuth and elevation from the ground-based sensor's point of view.) The question then becomes, "How can the data be processed so that the expert *can* make a decision?" In this report, two data processing techniques were investigated. The first technique used statistical information concerning the residuals while the other used the residual probability data. (The raw residual data from the five Kalman filters for trajectories one through six are presented in Appendix A.)

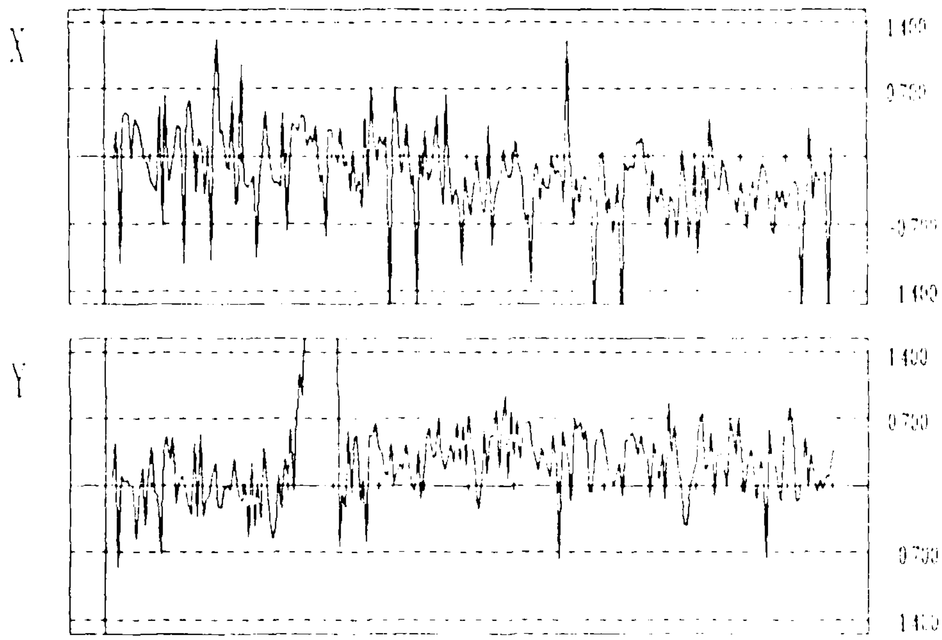


Figure 6. Kalman Filter Number One Residual Data from Trajectory Two.

3.4.1 Statistical selection criterion. One approach to selecting the best Kalman filter would be to perform some type of temporal analysis of previous filter residuals, looking for some type of trend. Dr. Maybeck stated that information available in the residuals could conceivably be used to select a filter that would provide an estimate as good as, and possibly better than, the filter having the highest residual probability. The candidate residual statistics chosen by Dr. Maybeck were:

1. Mean.
2. Slope.
3. Percent mean crossing.
4. Gaussianess.
5. Scaled residual.
6. Average scaled residual.

These statistics (except for Scaled residual) were computed using the previous N residual points. N was originally selected by the expert to be 15. This corresponded to a 0.5 second time interval within the 8.0 second simulation. Mean refers to the average of the previous N residual values. Slope is the slope of the line that is the least squares fit approximation of the last N residual values. Examples of these statistics are shown in Figures 7 and 8. Percent mean crossing is calculated by first counting the number of times the last N residuals crossed the mean value of those N residuals. Thus if $r(t_i)$ and $r(t_{i+1})$ were, respectively, less than and greater than the average of the previous N residuals, the count would increase by one. This total is incremented by one and then divided by N, resulting in the percent mean crossing value. This statistic was used as an estimate of signal whiteness. The higher the percent mean crossing, the more likely the values are not time-correlated (and therefore are white). Gaussianess refers to some type of numeric representation of the likelihood that the last N residual data points had a Gaussian distribution. Scaled residual is the value of the square of the residual divided by the associated component of $\hat{A}$. $\hat{A}$ is the filter-computed covariance matrix of residual $r(t_i)$ (see

Figure 4) conditioned on residuals taken through t_{i-1}. (For more information see [10, Section 5.3].) Average scaled residual is the average of the previous N scaled residuals. Dr. Maybeck stated that the residuals coming from a filter with a very good internal model and assumed parameters should have zero mean and zero slope, be white, have a Gaussian distribution, and have scaled residual values equal to one [13].

By computing these statistics and comparing them to the desired characteristics, the filter selection process could theoretically select the filter having attributes most like those of the ideal filter. In addition, any information concerning relationships between filters could also be included as part of the selection process. For example, a developer may conclude that when filter X residuals have a negative mean and filter Y residuals have a large slope, that the system should select the state estimate from filter Z.

3.4.2 Residual probability selection criterion. An alternative selection guideline would be to analyze the residual probabilities for information germane to the filter selection process. An example of the residual probabilities developed by an MMAF system is shown in Figure 9. The abscissa of this figure runs from zero to eight seconds (with marks every half second), while the ordinate runs from zero to one. The figure shows the five filter residual probabilities superimposed on each other with numbers provided to differentiate between the probability curves.

The current technique, MAP, selects the filter with the highest probability. Thus, in Figure 9, MAP would first select filter number one until just after one second at which time it would switch to filter number four. This would then continue for the entire trajectory. An expert system based upon residual probability data could have rules that did more than just find which filter had the highest residual probability. Rules could be tailored depending upon which filters had recently been selected. For example, if the system had been selecting filter number one and suddenly a different

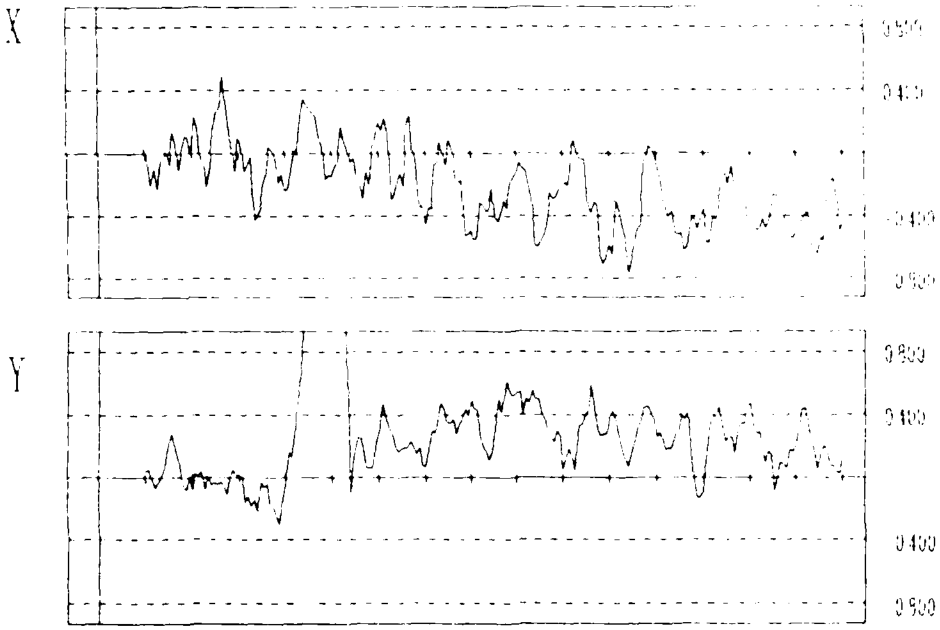


Figure 7. Filter One Residual Mean Statistics from Trajectory Two.

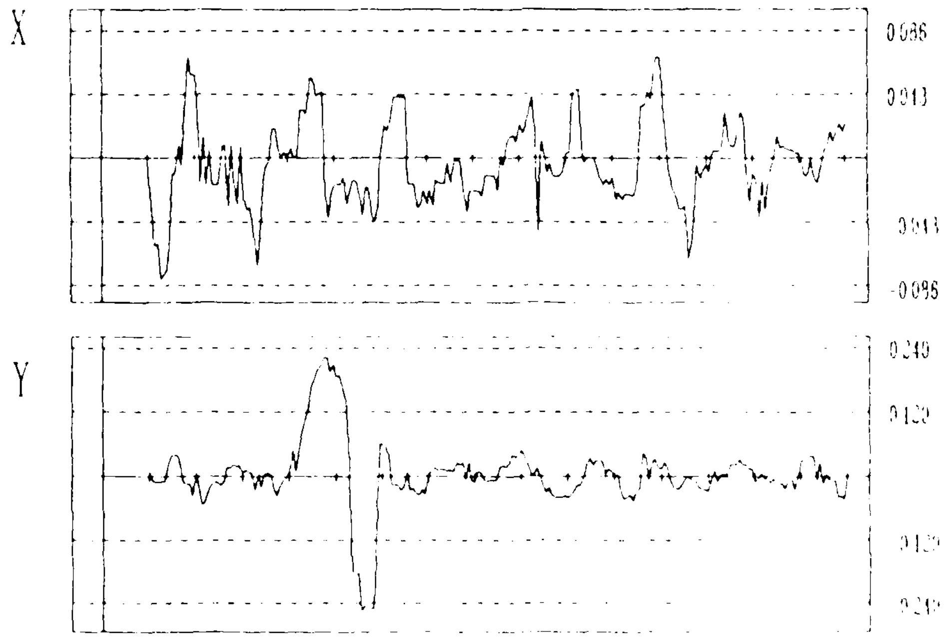


Figure 8. Filter One Residual Slope Statistics from Trajectory Two.

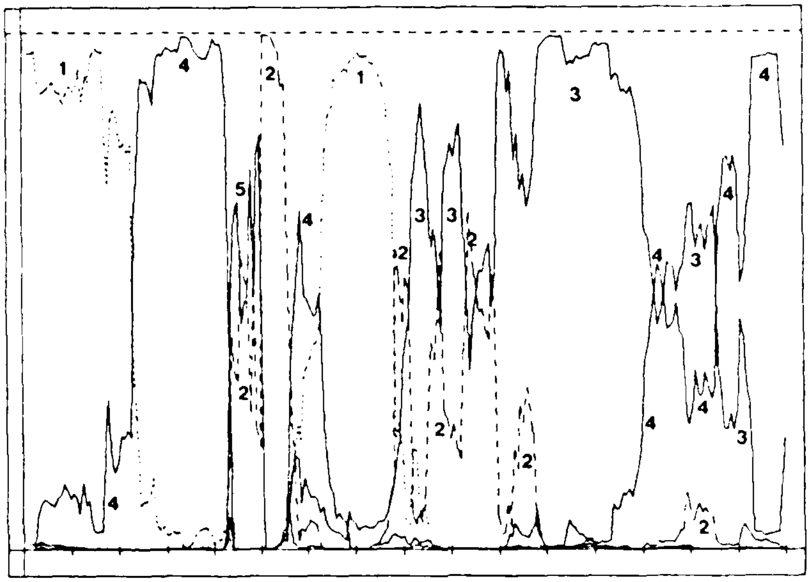


Figure 9. Residual Probabilities from Trajectory Two.

filter has a residual probability that is only slightly greater than filter one, the "best" filter may be still filter number one. Rules could also take into account any tendencies of the original system to prefer one filter over another when the parameters from those filters may be equally likely. For example, if the original system tends to go toward filter two over filter one, select filter one if the filters' residual probabilities are "close enough." This criterion may be especially helpful since it clearly shows when each filter "believes" it has good and poor estimates.

3.5 Chosen filter selection criterion.

The residual probability selection criterion was selected as the basis for the filter selection expert system.

The statistical process seemed very promising at first. Plots of the statistics identified in Section 3.4.1 were developed from a multiple-model Kalman filter software program [21]. This program simulated five tuned filters. Each simulated eight-second trajectory generated 30 plots (five filters, each having six statistics).

The plots from trajectory two are shown in Appendix B. Certain gross characteristics could be identified in the plots. For example, Dr. Maybeck stated that when a filter had a very poor assumed model, its residual would have a relatively large absolute value. This phenomenon was exhibited in the mean, slope, and scaled residual plots. Examples of the mean and slope statistics are shown in Figures 7 and 8. In trajectory two, a 10-g pull-up is initiated at time 2.0 seconds. Since filter number one is tuned for benign targets, the residuals from this filter become very poor in the Y-direction (elevation) during the 10-g pull-up. Clearly, filter one is not the filter of choice between time 2.2 and 2.6 seconds. However, there were no clear indications in the statistics when a filter was doing moderately well or better. Thus, one or two filters could often be ruled out, but this still left several from which to select. For example, the MAP selection criterion adamantly picked filter one between time 3.2 and 3.8 seconds during trajectory two. Unfortunately, while reviewing the statistics from each of the filters (Appendix B) over this time interval, nothing pointed to filter one as being the best. An additional problem was the time-lag produced by using previous filter residuals in developing most of the statistics. (Only the scaled residual statistic was based solely on the current residual.) Initially, the previous 15 residuals were used in determining the residual mean, slope, percent mean crossings, Gaussianess, and average scaled residual values. These statistics were recalculated using just the previous five residuals in hopes that the resulting statistics would be more responsive to changes in the residuals. A review of the new plots showed that they were no more helpful than the old plots.

Plots of the residual probability values were also developed. These plots are shown in Appendix C. Each plot contained five curves, representing the time domain residual probabilities of the five Kalman filters during the simulation. From these plots it was clear which filter the current selection technique would chose (the filter with the highest probability) and which filters had strong probabilities, though not necessarily the greatest. Using information available in these plots, and knowledge

about the Kalman filters simulated in the software, Dr. Maybeck believed that he could develop criteria to select the best filter, enhancing performance above that attainable by just using the MAP criterion.

Since the expert could develop rules based upon the information available in the residual probabilities plots, this was the source of data chosen for the expert filter selection process.

IV. Software Development.

4.1 Overview of software system.

Three computer programs were developed as part of the overall software system. These programs are graphically portrayed in Figure 10. The Kalman filter program has been adapted from the program used by [21] and currently runs on the AFIT ICC computer. This FORTRAN program has been modified so that the residual probabilities are written to a file (fltrprob). In addition, new trajectories were added to provide additional test cases for the expert system. The file fltrprob is read by both the expert system and the SUN graphics program, filtsel.c. Filtsel.c draws a graph of the residual probabilities of each filter. This graphics program is written in C and provides a hardcopy capability. The expert system, known as KREST (Kalman filter Residual Expert SysTem) is written in OPS-5 and runs on the AFIT SSC computer. The results of the expert system are saved in the file KRESTOut. This file contains the filter selected by the original system and by KREST, and the values of the five filter residual probabilities. If the filter chosen by KREST is different than that of the original system, the KRESTOut file also shows the number of the rule that made that decision.

4.2 Kalman filter software.

The goal of the original Kalman filter program (Kalresid.f) was to address:

> ...the problem of accurately tracking the azimuth and elevation of a highly maneuverable airborne target, using outputs from a forward-looking infrared (FLIR) sensor as measurements [21, p.1].

To do this, the program simulates five Kalman filters receiving data from a single sensor. The filters are tuned for different models of targets. For example, filter one is tuned for a benign target, while filter two is tuned for a harshly maneuvering

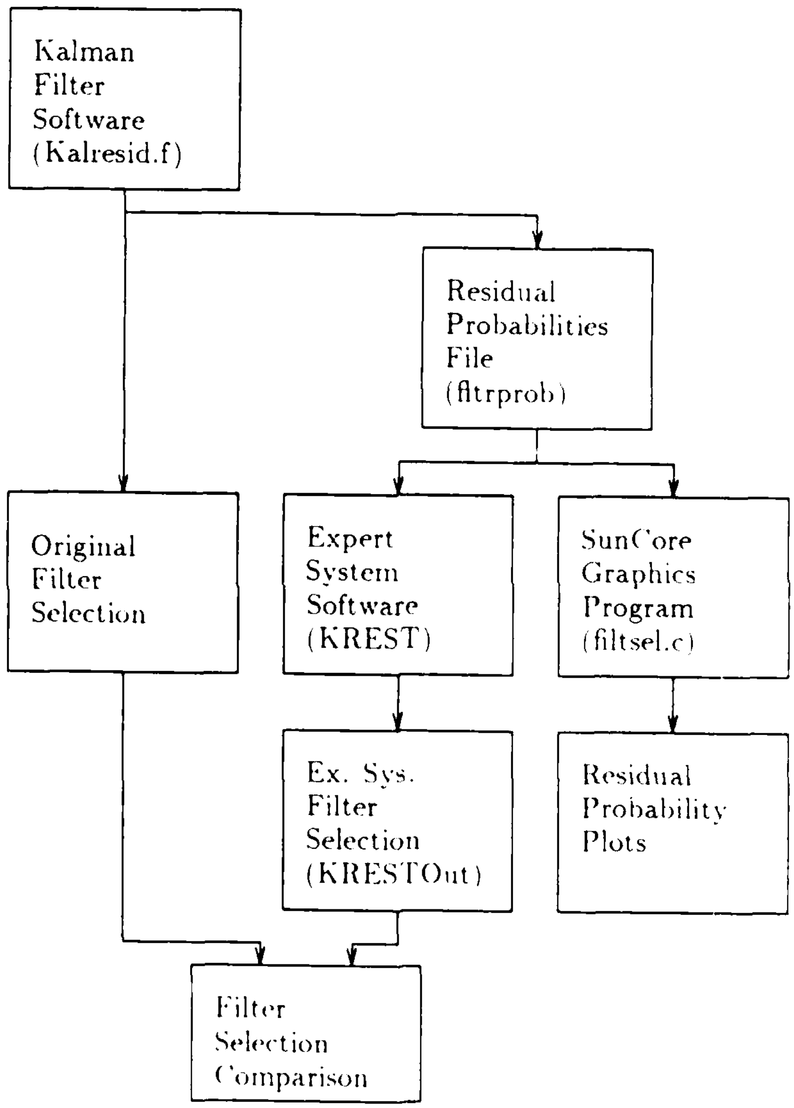


Figure 10. Software System Block Diagram.

target. Since the filters are independent, the program could be modified to allow for multiple sensors each with its own set of filters. Additionally, the program could be adapted to allow for fusing simulated sensor data in individual Kalman filters. Since a "proof of concept" expert system could be developed without adding this multi-sensor capability, the original program was not modified.

The crux of the tracking problem is to maintain high precision location and velocity information on the target during benign phases, while not losing lock during periods of harsh maneuvering or sustained acceleration [21, p.1]. By adaptively selecting the best filter, the system should be able to reach these objectives.

Each filter has a spatial tracking window and target acceleration model associated with it. The windows are rectangles with sides of eight or 20 pixels (a pixel is 20 μrads by 20 μrads). The target acceleration models are tuned for either 0-, 10-, or 20-g maneuvers. The characteristics of the five filters used in the FLIR tracking software are shown in Table 3.

Table 3. Simulated Kalman Filter Characteristics.

Filter Number	Field of View (az x el)	Target Acceleration Model	Target Model
1	8x8	0-g	benign
2	24x24	20-g	harsh maneuver
3	8x8	10-g	smooth maneuver
4	24x8	20-g (az)	azimuthal maneuver
5	8x24	20-g (el)	elevational maneuver

At each time interval during the simulation, the five filters develop state estimates of the target based upon simulated FLIR sensor data. The goal of the expert system is to select the filter with the best state estimate.

4.3 Selection of Expert System Approach.

The expert system could have been developed using an AI framework. (e.g., rule-based or frame-based programming), or a conventional programming approach. (e.g., functional decomposition, top-down, etc.). Discussions with the expert indicated that the knowledge would not require an extensive decision tree or any type of inheritance network. Thus, a traditional programming language could have been chosen. However, an AI framework can be especially helpful in developing rapid prototype software which gracefully evolves as knowledge is added and deleted. The currently available expert system shells can be especially helpful in tracing through the logic of the expert system for debugging purposes. This is also very helpful in the development of rapid prototype software.

Based upon the ease of knowledge encoding and subsequent debugging, an AI approach was selected as the basis for the Kalman filter selection expert system.

The selection of the specific expert system development tool was based upon the characteristics of the problem and availability of the tool. The tools considered were: OPS-5, ART, KEE, and LISP. OPS-5 and ART are rule-based development tools. KEE provides a frame-based expert system language. The LISP computer language is very flexible, allowing for either type of representation.

Two factors led to the selection of a rule-based approach. First, while considering the feasibility of an expert system to assist in the Kalman filter selection process, Dr. Maybeck stated that he believed he could develop several "rules" to make filter selections. Second, while reviewing the plots of residual probabilities, Dr. Maybeck was able to identify conditions when certain filters should be selected. These conditions were usually described as "If this and this and this, then this." This type of knowledge is easily represented using rules. Thus, only the rule-based languages and LISP were considered further.

The remaining languages then were: OPS-5, ART, and LISP. Although LISP is

flexible, it is also very simplistic. If LISP was selected, some type of inference engine and conflict resolution function would need to be developed. Since both OPS-5 and ART had these capabilities built-in, LISP was rejected. Finally, since the Kalman filter software was running on an AFIT Unix-based machine, OPS-5 was selected due to its availability on the AFIT SSC computer.

4.4 Expert knowledge/Rule development.

Once the source of data for the expert system was established (residual probabilities instead of residual statistics), the rules themselves were fairly easy to develop. In general, the rules apply when one filter is losing confidence in its estimates while another filter is gaining or when two or more filters are "fighting" to be selected. This latter case occurs when the better filters have residual probabilities that remain close in value with no single filter standing out.

Depending upon the circumstances, certain filters are better to use than others. Since the expert knows when it is advisable to use certain filters, rules can be developed based upon this knowledge. Thus, although the rules test for certain residual probability values, the underlying basis for the rules is the expert's knowledge about the characteristics of the filters. Consider the five simulated Kalman filters. Filter one has a narrow beamwidth and is tuned for zero-g maneuvers. Thus, this filter should be used with benign targets to provide high precision state estimates. Filter two has a wide beamwidth and is tuned for 20-g maneuvers. This filter is especially useful when the target is pulling a high-g maneuver since the large beamwidth and filter tuning should keep it from losing track on the target. Filter three has the same narrow beamwidth as filter one, however this filter is tuned for 10-g maneuvers. This filter is a kind of compromise between the high precision estimate of filter one and the robust tracking capability of filter two. Filter four has a wide beamwidth in azimuth and a narrow one in elevation. This allows the filter to track targets that are accelerating primarily in the azimuth direction. Filter five is just the opposite. This

filter has a narrow beamwidth in azimuth and a wide one in elevation allowing for targets that are accelerating primarily in elevation. These azimuthal and elevational accelerations are with respect to the sensor's coordinate space which is assumed to be fixed on the ground.

There are two, possibly conflicting, requirements for the tracking system. First is the desire to have target state information with as high a precision as possible. Second is the desire to never lose track of the target, since this would send the tracking system into a time consuming search mode to reacquire the target. Filters one and three provide the best precision estimates. Filter two provides the least likelihood of losing the target. Thus, there were two general guidelines for developing the rules. First, if filters one or three are doing a fairly good job of tracking the target, select one of them. Second, if the target has apparently done some type of maneuver and the system is not quite sure which filter to select, select filter two.

Some of the KREST rules were developed to overcome one of the inappropriate tendencies of the MMAF. This tendency is to stick with the harshly-maneuvering filters when the system should be selecting a benign filter. As Tobin stated, "...[the MMAF] was somewhat more hesitant to reduce the bandwidth to an appropriate benign level when the target comes out of a turn, compared to the speed with which it opens the bandwidth at the onset of a pullup" [21, p.19]. Thus, to compensate, many of the KREST rules where developed to favor the less-harsh filters.

4.5 Expert system (KREST) overview.

KREST contains both LISP functions and OPS-5 rules. The LISP functions were developed to determine certain state characteristics. The OPS-5 rules fall into five separate categories. These categories are:

1. Initializing.
2. Updating.
3. Scheduling.

4. Residual Probability Rules.
5. Printing.

The initializing rule defines and pre-sets certain variables in addition to reading in header information from the data file. The updating rule reads in the next set of residual probabilities. The scheduling rules are needed to make the other types of rules fire in the proper sequence. The residual probability rules are the actual expert rules developed from discussions with Dr. Maybeck. The final version of KREST contained just ten rules related specifically to selecting filters. The printing rule is used to display the filter selected by KREST as well as other pertinent information.

The filter selection done by KREST is sent to the file KRESTOut. No attempt has been made to have KREST run concurrently with the original Kalman filter simulation software. The expert filter selection is done on a post-processing (also known as open loop) basis. In reality, the real-time selection of the "best" Kalman filter does have an effect on the generation of filter residuals. As such, to fully test the KREST filter selection process the new algorithm would need to be included in the original simulation software. Once this was accomplished, analysis could be performed on the control signal being developed on a closed-loop basis. This control signal is of prime importance since it is used, theoretically, to point the IRST/Laser system. One of the best ways to evaluate the performance of the filter selection expert system would be to compare the control signal time history developed from the KREST-based system versus the control signal time history resulting from a MAP-based system. As stated previously, no attempt was made to incorporate this closed-loop feature in the original simulation software.

4.6 Test Cases.

The rules developed for KREST came from the residual probability graphs from ten trajectories. Trajectories one through four were provided in the original software. Trajectories five and six were developed to stress the filter selection process. While

trajectories one through six simulate targets moving primarily in azimuth, trajectories seven and eight simulate primarily elevational motion and trajectories nine and ten simulate a diagonal motion. These trajectories are described in Table 4. Plots of these trajectories are included in Appendix A. The purpose of these trajectories is not to simulate specific known threats, but rather to exercise the filter selection processes (MAP and KREST) under diverse conditions. This was intended so that the Kalman filter expert would develop rules that applied to fairly random target trajectories.

Table 4. Target Trajectory Characteristics.

Traj.	Target Motion	Loc. at time=0.0 (km)	Vel. at time=0.0 (km/sec)	Acc. at time=2.0 (G's)	Acc. at time=3.5 (G's)
1	straight	5.0 X	-1.0 X	0.0	0.0
		0.5 Y	0.0 Y		
2	circular	5.0 X	-1.0 X	10.0	10.0
		0.5 Y	0.0 Y		
3	circular	5.0 X	-1.0 X	10.0	0.0
		0.5 Y	0.0 Y		
4	circular	5.0 X	-1.0 X	10.0	10.0
		0.5 Y	0.0 Y		
5	circular	5.0 X	-1.0 X	10.0	-10.0
		0.5 Y	0.0 Y		
6	parabolic	5.0 X	-1.0 X	20.4 X	1.0 X
		0.5 Y	0.0 Y	20.4 Y	-1.0 Y
7	parabolic	0.5 X	0.0 X	-2.0 X	0.0 X
		0.0 Y	1.0 Y	-2.0 Y	0.0 Y
8	parabolic	0.5 X	0.0 X	-2.0 X	1.0 X
		0.0 Y	1.0 Y	0.0 Y	0.5 Y
9	parabolic	2.0 X	-0.5 X	-5.1 X	-7.7 X
		0.0 Y	0.5 Y	5.1 Y	0.0 Y
10	parabolic	2.0 X	-0.5 X	10.2 X	2.0 X
		0.0 Y	0.5 Y	1.0 Y	2.0 Y

V. Results and Conclusions.

5.1 KREST Results.

The purpose of KREST is to assist in the MMAF filter selection process. The system was designed to be especially helpful in those instances when the MAP selection criteria does a poor job. Some of these situations are identified in Table 5.

Table 5. Problematic Filter Selection Instances.

1. Transitions from the high-g filter (No.2) to the benign filter (No.1).
2. Transitions from the high-g filter (No.2) to the moderate-g filter (No.3).
3. Transitions between the X-oriented (No.4) and the Y-oriented (No.5) filters.

The expert system filter selections for ten target trajectories are shown in Appendix E. Portions of these results are also shown in Tables 7 through 15. In these tables: Time is the specific time interval; Rule is the number of the KREST rule that fired, if any; KF is the filter KREST selected; MAP is the filter selected by the maximum a posteriori selection process (the filter with largest residual probability); and P1 through P5 are the residual probabilities of filters one through five, respectively.

It should be noted that trajectories one through four were not modified from those used in previous research [21] [9]. Trajectories five through ten were developed with harsh-g maneuvers to cause the MAP-based system to select the "wrong" filter.

KREST filter selections differ from those chosen by the MAP selection criteria when the original system lingers on overly dynamic filters and during transition periods between filters. By tending towards the less dynamic, narrower field of view (FOV) filters, KREST has helped overcome the natural tendency of the MMAF system to stick on high-g filters. By selecting square FOV filters when the perpendicularly oriented filters have significant residual probabilities, KREST also provides a means of smoothing the filter selection sequence. For example, this may result in

the selection of a square filter after an X-oriented filter and just before a Y-oriented filter, providing a smoother transition.

5.1.1 Propensity toward benign filters. Rules 30 and 55 (Table 6) are examples of KREST rules developed to compensate for the original system's tendency to adhere to non-benign filters. These rules select filter three when the residual probabilities of filters two and three met certain constraints. (Note: The precondition Best=2 in Rule 50 is satisfied when the residual probability of filter two is larger than all others. The precondition Best=3 for last 3 or more in Rule 30 is satisfied when KREST has selected filter three during the previous three time intervals.) Table 7 demonstrates that these rules make the system tend toward the narrower FOV filters. While the original system occasionally selects filter two following time 119, KREST sticks with filter three based upon the significant residual probability of that filter. Balanced with the desire for improved tracking resolution is the need to keep track of the target. Thus, while this type of rule "encourages" the use of narrow FOV filters, it do not overly restrict the system when the use of a wider FOV filter is indicated. The thresholds were set in Rules 30 and 55 to achieve this balance.

Table 6. KREST Rules 30 and 55.

Rule	Precondition	Filter
30	If Best=3 for last 3 or more and the new Best=2 and $P2 < 0.7$ and $P3 > 0.2$	3
55	If Best=2 and $P3 > 0.25$	3

Table 7. KREST Results for a Portion of Trajectory Two.

Time	Rule	KF	MAP	P1	P2	P3	P4	P5
116		1	1	0.781	0.101	0.092	0.001	0.025
117		1	1	0.721	0.123	0.126	0.001	0.029
118		2	2	0.213	0.580	0.179	0.004	0.025
119		2	2	0.243	0.522	0.211	0.004	0.021
120	55	3	2	0.165	0.438	0.370	0.003	0.024
121	55	3	2	0.057	0.524	0.408	0.002	0.009
122	55	3	2	0.045	0.499	0.446	0.002	0.007
123		3	3	0.193	0.066	0.712	0.008	0.021
124		3	3	0.190	0.046	0.737	0.007	0.019
125		3	3	0.098	0.067	0.815	0.014	0.006
126		3	3	0.052	0.063	0.867	0.015	0.004
127		3	3	0.086	0.106	0.783	0.018	0.007
128		3	3	0.018	0.270	0.695	0.014	0.003
129		3	3	0.006	0.399	0.582	0.008	0.004
130		3	3	0.006	0.365	0.620	0.007	0.002
131		3	3	0.003	0.470	0.520	0.006	0.002
132	30	3	2	0.001	0.575	0.419	0.001	0.004
133		3	3	0.002	0.263	0.730	0.003	0.002
134		3	3	0.001	0.250	0.748	0.001	0.001
135		3	3	0.001	0.213	0.784	0.001	0.001
136		3	3	0.001	0.241	0.755	0.001	0.001
137		3	3	0.001	0.190	0.807	0.001	0.001
138		3	3	0.001	0.173	0.824	0.001	0.001
139		3	3	0.001	0.383	0.613	0.001	0.001
140		3	3	0.001	0.467	0.530	0.001	0.001
141	30	3	2	0.001	0.651	0.346	0.002	0.001
142	30	3	2	0.001	0.546	0.450	0.001	0.001
143	30	3	2	0.002	0.519	0.477	0.001	0.002
144		3	3	0.001	0.458	0.538	0.001	0.001
145		3	3	0.001	0.463	0.533	0.001	0.001
146		3	3	0.001	0.427	0.570	0.001	0.001
147		3	3	0.001	0.405	0.592	0.001	0.001
148	30	3	2	0.001	0.529	0.468	0.001	0.001
149		3	3	0.001	0.460	0.536	0.001	0.001
150		3	3	0.001	0.061	0.935	0.002	0.001
151		3	3	0.002	0.027	0.966	0.004	0.001

Rule 40 (see Table 8) was also developed to give KREST a propensity toward the more-benign filters. In this case, the desire is to select the non-maneuver filter (number one) over the moderate maneuver filter (number three). Table 9 shows several occasions where KREST used this rule to determine that filter one had a sufficient residual probability level to warrant its selection. While these selections may not result in a startling increase in performance, some improvement is expected.

Table 8. KREST Rule 40.

Rule	Precondition	Filter
40	If Best=3 and P1 > (P3 * 0.5) and P1 is increasing.	1

Table 9. KREST Results for a Portion of Trajectory Seven.

Time	Rule	KF	MAP	P1	P2	P3	P4	P5
23		3	3	0.222	0.049	0.612	0.079	0.038
24		3	3	0.280	0.038	0.575	0.077	0.030
25	40	1	3	0.344	0.022	0.525	0.077	0.032
26		3	3	0.063	0.040	0.756	0.133	0.009
27		3	3	0.155	0.016	0.716	0.095	0.018
28	40	1	3	0.337	0.012	0.542	0.060	0.050
29	40	1	3	0.392	0.006	0.487	0.058	0.057
30		3	3	0.329	0.002	0.570	0.040	0.060
31	40	1	3	0.370	0.002	0.498	0.038	0.092
32	40	1	3	0.372	0.001	0.452	0.026	0.148
33		3	3	0.362	0.001	0.498	0.018	0.121
34	40	1	3	0.378	0.001	0.481	0.014	0.126
35		3	3	0.246	0.005	0.681	0.008	0.060
36	40	1	3	0.412	0.001	0.519	0.001	0.071
37		3	3	0.318	0.003	0.462	0.001	0.185
38	40	1	3	0.370	0.003	0.484	0.001	0.143
39	40	1	3	0.381	0.001	0.475	0.001	0.141
40		1	1	0.471	0.001	0.366	0.001	0.161
41		1	1	0.512	0.001	0.268	0.001	0.218

5.1.2 Smoother filter transitions. The purpose of KREST Rules 25, 70, and 75 (see Table 10) was to provide for smoother transitions between the orthogonal filters four (X-oriented) and five (Y-oriented). The expert has determined that if both of these filters have significant residual probability values, that the best choice would be one of the square FOV filters. Specifically, the system should select either filter one with its narrow, square FOV or filter two with its large, square FOV. Rules 70 and 75 were developed with similar preconditions, the difference being that Rule 70 selects filter one and Rule 75 selects filter two. The filter with the higher residual probability determines which rule fires. An example of KREST's use of this type of rule is shown in Table 11. Whereas the original system transitioned directly from filter five to filter four at time 162 and back to filter five at time 165, KREST provided a smoother transition by using filter one.

Originally, no minimum thresholds were set for the selected filter. As a result, Rule 70 fired during the time interval of 152 to 155 in Table 11. These times are indicated by a dash in the Rule column. Dr. Maybeck observed that since neither filter one nor two had a residual probability above 0.07, neither should be selected. A better solution would be to let filters four and five "fight it out." The threshold values of the selected filters in Rules 70 and 75 were then set at 0.1 resulting in the desired rule firings between times 160 and 170.

Table 10. KREST Rules 25, 70, and 75.

Rule	Precondition	Selected Filter
25	If Best=4 or 5 and P1 > 0.3 and P1 is increasing.	1
70	If Best=4 or 5 and P1 < 0.6 and P5 < 0.6 and P3 < 0.2 and P1 > 0.1 and P1 > P2	1
75	If Best=4 or 5 and P4 < 0.6 and P5 < 0.6 and P3 < 0.2 and P2 > 0.1 and P2 > P1	2

Table 11. KREST Results for a Portion of Trajectory Three.

Time	Rule	KF	MAP	P1	P2	P3	P4	P5
151		5	5	0.136	0.001	0.017	0.054	0.791
152	-	5	5	0.038	0.034	0.011	0.353	0.564
153	-	5	5	0.048	0.025	0.012	0.338	0.577
154	-	5	5	0.051	0.008	0.010	0.369	0.562
155	-	5	5	0.061	0.006	0.009	0.392	0.532
156		5	5	0.058	0.005	0.010	0.254	0.673
157		5	5	0.034	0.005	0.008	0.165	0.787
158		5	5	0.038	0.005	0.008	0.150	0.800
159		5	5	0.038	0.004	0.007	0.127	0.824
160	70	1	5	0.128	0.001	0.011	0.346	0.514
161	70	1	5	0.141	0.001	0.008	0.344	0.506
162		4	4	0.021	0.029	0.007	0.856	0.086
163		4	4	0.032	0.013	0.010	0.834	0.112
164	70	1	4	0.125	0.019	0.018	0.481	0.357
165	70	1	5	0.174	0.004	0.014	0.282	0.526
166	70	1	5	0.212	0.003	0.015	0.297	0.473
167	70	1	5	0.186	0.003	0.014	0.308	0.490
168	70	1	5	0.195	0.003	0.029	0.336	0.437
169	70	1	5	0.189	0.002	0.030	0.372	0.406
170	70	1	5	0.217	0.002	0.030	0.362	0.389
171		3	3	0.123	0.005	0.507	0.173	0.192
172	40	1	3	0.287	0.001	0.355	0.098	0.259
173		1	1	0.402	0.001	0.294	0.066	0.237
174		1	1	0.488	0.001	0.203	0.062	0.245
175		1	1	0.550	0.001	0.160	0.054	0.236

Table 12 also shows a transition between filters four and five. Dr. Maybeck concluded that the filter selection done by KREST at times 65 and 66, that of selecting a broad FOV filter (No.2), provided a nice transition between these filters.

Table 12 also shows a transition from the wide FOV filter (No.2) and the narrow FOV filter (No.1). This transition occurs between times 82 and 97. The original selection process transitions through the X-oriented filter (No.4). Dr. Maybeck concluded that since filter one had a significant residual probability well before time 95, that filter should be selected earlier. The KREST selected filters were deemed appropriate by the expert.

Table 12. KREST Results for a Portion of Trajectory Five.

Time	Rule	KF	MAP	P1	P2	P3	P4	P5
62		4	4	0.018	0.001	0.001	0.979	0.001
63		4	4	0.037	0.001	0.003	0.956	0.002
64		4	4	0.033	0.025	0.015	0.869	0.058
65	75	2	4	0.019	0.160	0.063	0.446	0.312
66	75	2	5	0.001	0.411	0.001	0.001	0.586
67		5	5	0.001	0.337	0.003	0.001	0.657
68		5	5	0.001	0.325	0.001	0.001	0.672
69		2	2	0.001	0.561	0.001	0.001	0.436
70		2	2	0.001	0.519	0.001	0.001	0.478
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
82		2	2	0.024	0.894	0.018	0.035	0.029
83		2	2	0.019	0.900	0.014	0.041	0.026
84		2	2	0.100	0.532	0.079	0.206	0.082
85	75	2	4	0.145	0.307	0.133	0.402	0.013
86	70	1	4	0.187	0.164	0.180	0.461	0.008
87	70	1	4	0.238	0.017	0.175	0.568	0.002
88		4	4	0.212	0.040	0.088	0.656	0.005
89	25	1	4	0.332	0.035	0.139	0.492	0.004
90	25	1	4	0.350	0.045	0.117	0.484	0.005
91	25	1	4	0.370	0.056	0.099	0.468	0.007
92	25	1	4	0.395	0.049	0.102	0.449	0.005
93	25	1	4	0.399	0.045	0.097	0.453	0.005
94	25	1	4	0.431	0.005	0.069	0.494	0.001
95		1	1	0.634	0.001	0.081	0.283	0.001
96		1	1	0.771	0.001	0.049	0.177	0.001
97		1	1	0.839	0.001	0.040	0.118	0.002
98		1	1	0.856	0.001	0.033	0.108	0.002
99		1	1	0.909	0.001	0.033	0.056	0.001

The purpose of trajectory six was to force the simulated target into a diagonal motion in an attempt to make the original system alternate between the X-oriented (No.4) and the Y-oriented (No.5) filters. The residual probabilities from trajectory six are graphically shown in Figure 11. Due to the kinematics of the trajectory, the system has difficulty selecting filters between times 183 and 208 (see Table 13). For example, at time 184 filters one, two, and five have residual probabilities of approximately 0.26, 0.21, and 0.29, respectively. At time 188, filters one, four, and five have residual probabilities of approximately 0.21, 0.28, and 0.30, respectively. Any filter selection based solely upon the maximum of these close values would be more chance than anything else. Rules 70 and 75 again provide a mechanism for smoothing the transition between filters two and one while allowing other filters with significant residual probabilities (e.g., filter five between 192 and 195) to be selected when appropriate.

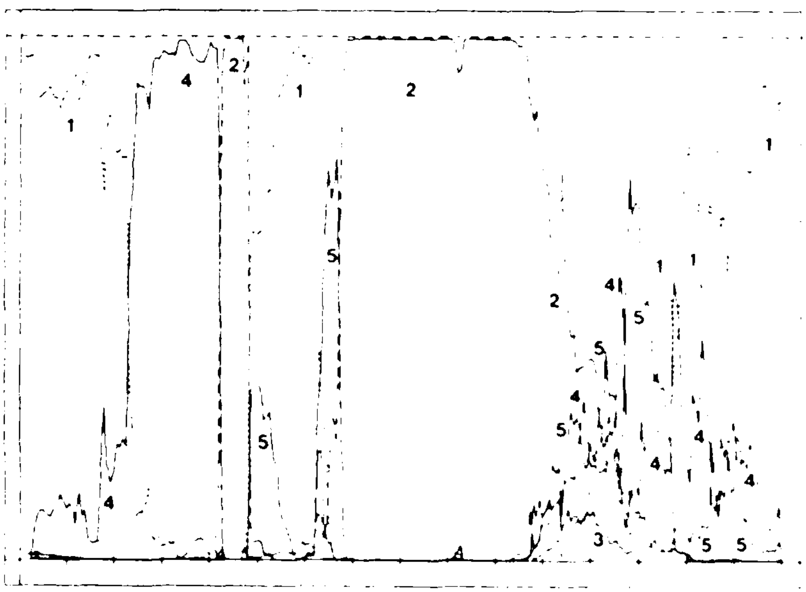


Figure 11. Residual Probabilities from Trajectory Six.

Trajectories seven through ten were developed to test the expert system against dramatically different target motions. While trajectories one through six [illegible]

Table 13. KREST Results for a Portion of Trajectory Six.

Time	Rule	KF	MAP	P1	P2	P3	P4	P5
180		2	2	0.131	0.385	0.085	0.177	0.222
181		2	2	0.151	0.382	0.094	0.183	0.190
182		2	2	0.190	0.358	0.068	0.175	0.210
183	75	2	5	0.212	0.268	0.067	0.167	0.287
184	70	1	5	0.255	0.214	0.064	0.174	0.293
185	75	2	5	0.159	0.222	0.054	0.166	0.399
186	75	2	5	0.133	0.276	0.032	0.248	0.311
187	75	2	5	0.177	0.235	0.033	0.237	0.318
188	70	1	5	0.213	0.167	0.041	0.276	0.303
189	75	2	4	0.085	0.206	0.026	0.545	0.139
190	70	1	4	0.130	0.120	0.025	0.538	0.186
191	70	1	5	0.127	0.062	0.015	0.349	0.447
192		5	5	0.052	0.086	0.015	0.103	0.743
193		5	5	0.052	0.138	0.020	0.130	0.661
194		5	5	0.058	0.092	0.020	0.143	0.688
195		5	5	0.080	0.096	0.023	0.121	0.680
196	70	1	5	0.115	0.081	0.028	0.272	0.504
197	70	1	5	0.199	0.086	0.031	0.198	0.487
198	70	1	5	0.243	0.035	0.028	0.196	0.499
199	70	1	5	0.293	0.032	0.029	0.210	0.436
200		1	1	0.351	0.042	0.019	0.246	0.342
201	70	1	5	0.345	0.031	0.019	0.248	0.358
202		1	1	0.389	0.024	0.018	0.243	0.326
203		1	1	0.468	0.020	0.018	0.161	0.333
204		1	1	0.546	0.019	0.020	0.176	0.239
205		1	1	0.570	0.018	0.015	0.168	0.228
206	70	1	4	0.337	0.049	0.024	0.537	0.052
207	25	1	4	0.389	0.017	0.019	0.512	0.062
208		1	1	0.487	0.014	0.018	0.412	0.070
209		1	1	0.707	0.016	0.017	0.195	0.066
210		1	1	0.739	0.011	0.015	0.181	0.053

basically horizontally moving target, trajectories seven and eight simulated primarily vertical motions and trajectories nine and ten tested primarily diagonal motions. Analysis of the KREST results for these new trajectories showed that the current rules were adequate. No new rules could be developed from the results and all rules that did fire were deemed appropriate by the expert.

Trajectories seven through ten did, however, prompt one change to the rule-base. Early discussions with the expert led to the development of several rules that attempted to catch transitions between the X-direction filter (No.4) and the Y-direction filter (No.5). These rules are shown in Table 14. The general idea was to find instances where the MAP selection criteria had selected one of these filters for several time periods and then attempted to transition directly to the other, orthogonal filter. If this was attempted while the wide FOV filter (No.2) had a significant residual probability, then the expert wanted to select that wide FOV filter. Three rules were developed, one checking for transitions from filter four to filter five (Rule 10), another checking for transitions from filter five to filter four (Rule 15), and a third checking for a history of alternating between filters four and five (Rule 20). Originally, these rules would occasionally fire. However, as faster rules were developed (those that did not require a history of certain filters being selected) these historical rules no longer applied. As an example, Table 12 shows a transition between filters four and five at time interval 65. The first of these historical rules checked for a series of selecting filter four before going to filter five. This condition would have occurred at time 66, except for the fact that Rule 75 has fired at time 65 selecting filter two. This defeats the precondition of the historical rule and precludes it from firing. Trajectories seven through ten confirmed that, at least for those cases, the historical rules had been superseded by some of the later rules. Thus, Rules 10, 15, and 20 were deleted.

Table 14. Historical Rules.

Rule	Precondition	Selected Filter
10	If Best=4 for last 3 or more and the new Best=5 and P2 > 0.2 then	2
15	If Best=5 for last 3 or more and the new Best=4 and P2 > 0.2 then	2
20	If Best=4 for 2 or more of last 5 and Best=5 for 2 or more of last 5 and P2 > 0.2 then	2

As with any expert system, any rule that has its precondition satisfied can fire. Thus, while the "Rule" column of the KREST results shows the one rule that fired, more than one rule may have had its preconditions met. While reviewing the results, if more than one rule applied, each applicable rule was checked to make sure there were no conflicts. "No conflicts" means that all of the rules that applied would have selected the same filter. In two cases there were conflicts. These conflicts occurred in trajectory six at time 183 (see Table 13) and in trajectory 10 at time 96 (see Table 15). In these cases Rules 60 and 61 attempted to select the narrow FOV filter (No.1) while Rule 75 attempted to select the wide FOV filter (No.2). The original purpose behind Rules 60 and 61 was to select filter one if it had a sufficient residual probability while the filter with the highest probability had a residual probability less than a certain threshold (see Table 16). Thus, if there was "confusion" over which filter to go with (since all filters had residual probability values below a certain level) the system would tend to go with filter one. Rules 70 and 75 were developed later on. The intent of these rules was to look for conflicts between the X-oriented (No.4) and Y-oriented (No.5) filters. When the specific preconditions were met, these rules selected either the narrow FOV filter (No.1) or the wide FOV (No.2) filter, depending upon which had the larger residual probability.

Table 15. KREST Results for a Portion of Trajectory Ten.

Time	Rule	KF	MAP	P1	P2	P3	P4	P5
92		2	2	0.053	0.833	0.016	0.049	0.048
93		2	2	0.067	0.813	0.019	0.051	0.051
94		2	2	0.071	0.386	0.020	0.370	0.154
95	75	2	4	0.113	0.248	0.027	0.467	0.145
96	75	2	4	0.202	0.243	0.045	0.330	0.180
97	70	1	4	0.258	0.211	0.051	0.278	0.202
98		1	1	0.333	0.156	0.054	0.263	0.193
99		1	1	0.382	0.170	0.053	0.207	0.188
100		1	1	0.475	0.093	0.056	0.210	0.165

Table 16. KREST Rules 60 and 61.

Rule	Precondition	Selected Filter
60	If PBest < 0.4 and P1 > 0.2 and P1 is increasing and Best <> Filter 1	1
61	If PBest < 0.4 and P1 > 0.2 and Best <> Filter 1	1

Dr. Maybeck reviewed the filter selection process where these anomalies occurred. In both situations, the original MAP selection process was transitioning from filter two to filter one. (Although in trajectory six, this transition took approximately twenty time intervals to complete.) In these cases it was not clear whether filter one or two was the better choice. As such, the expert decided to go with Rules 70 and 75 which allow filters one and two to "fight it out." Since Rules 60 and 61 could be removed with no effect on KREST's performance (other than at these two anomalistic occurrences), the rules were deleted.

5.2 *Conclusions.*

By analyzing the residual probability graphs of the five filters (see Appendix D), the expert (Dr. Maybeck) was able to express rules that selected the filters he desired. The resulting expert system, KREST, provided an improvement over the original MAP selection process. Although no quantitative estimate of improvement is available, Dr. Maybeck stated that KREST exhibited a "... potentially very significant performance improvement over the Bayesian and MAP filter selection techniques" [13].

This research has laid the foundation for the real question that needs to be asked: "Can advanced Kalman filter systems be used to facilitate sensor fusion?"

While KREST was not intended to answer that question directly, its performance indicates that expert knowledge can be used to improve the selection process of discrete filter models. In this research the filters have modeled different assumptions about the target's trajectory (e.g., filter one models a benign target while filter two models a high-g, maneuvering target). The filters could be changed to model assumptions about how sensor data from separate sources could be combined or contrasted. A KREST-like program could then be developed to select "sensor fusion" Kalman filters. The encouraging performance of KREST indicates that advanced MMAF systems infused with some type of expert knowledge, may help lesson the problems associated with sensor data fusion.

5.3 Recommendations.

There are several ways this research could be extended. These range from embedding the rules from the expert system into the original simulation software to making changes to the multiple model adaptive filters themselves.

Although the expert system shell (OPS-5) provided a flexible environment for testing and refining rules, the final version of the expert system required only ten domain-specific rules. As such, the current rulebase could easily be converted to a sequential computer language (e.g., FORTRAN) for inclusion in the MMAF simulation program. This is necessary for the system to be fully tested. Currently, KREST makes decisions on an open-loop basis. This means that KREST has no effect on the generation of the filter residual probabilities. By closing the loop (i.e., having KREST make selections as the MMAF simulation program runs through its Monte Carlo analysis) a numeric evaluation of KREST could be performed. Currently, the expert system is evaluated subjectively by the expert. Since the location of the simulated target and the estimates of each filter can be obtained, the best filter at each time interval could be identified. This would then provide a numeric evaluation of the expert system's performance. Once the numerically best filters have been

determined, this knowledge could be used by the expert to modify KREST's rules.

Some type of explanation system should be developed so that KREST can provide the person tuning the filters with some type of rationale as to why certain filters are being selected. This would be important since the filter selection process is based upon both the expert rules and the filter modeling.

Software should be developed to simulate Kalman filters receiving data from more than one sensor. This may be used to verify the usefulness of expert system-based MMAF selection as a solution to the sensor fusion problem. Rules for the expert system could be based upon knowledge the expert has concerning specific sensor strengths and weaknesses. These rules might also consider what effect sensor degradation has on the resulting estimates.

Lastly, the use of an expert system such as KREST should be considered for other types of adaptive estimation and control tasks to further investigate the results of this research.

Appendix A. *Target Trajectory Plots.*

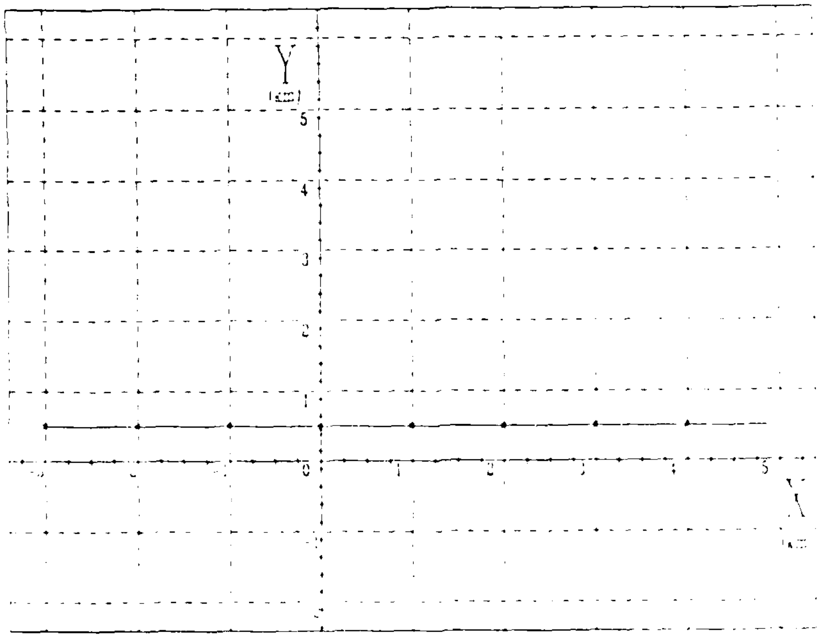


Figure 12. Target Trajectory Number One.

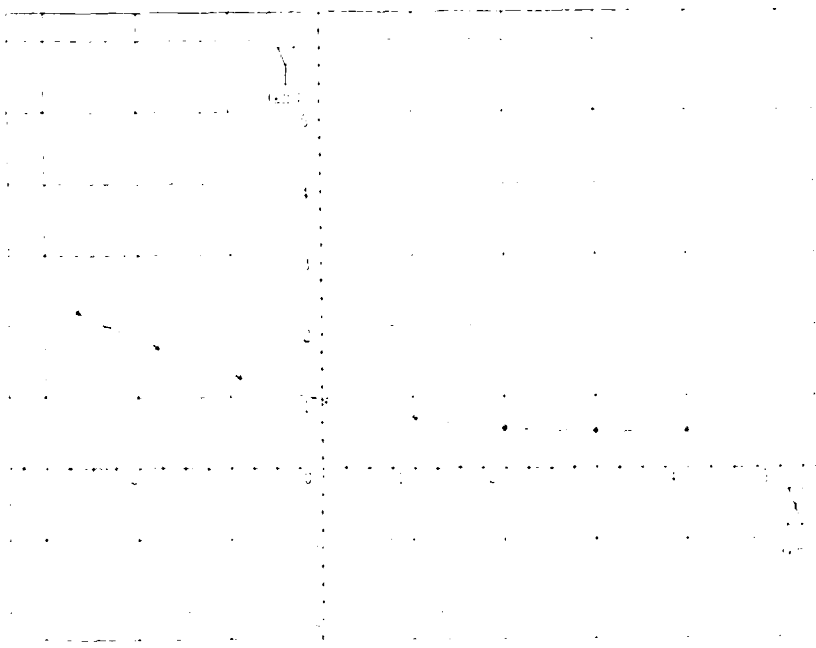


Figure 13. Target Trajectory Number Two.

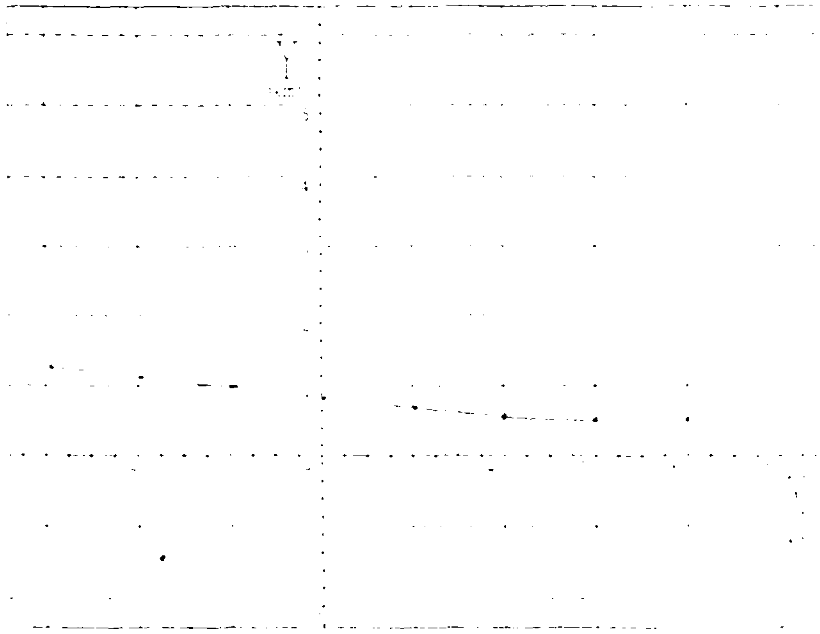


Figure 14. Target Trajectory Number Three.

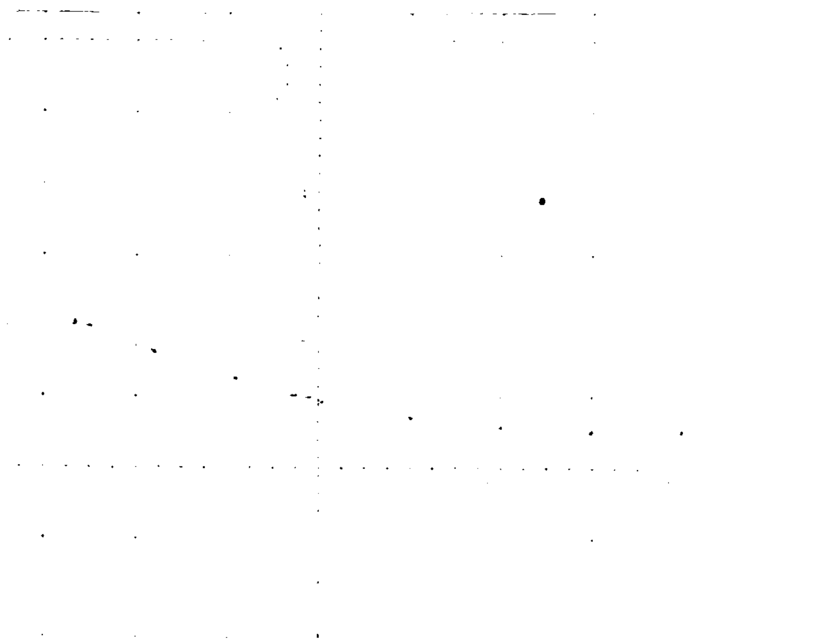


Figure 15. Target Trajectory Number Four.

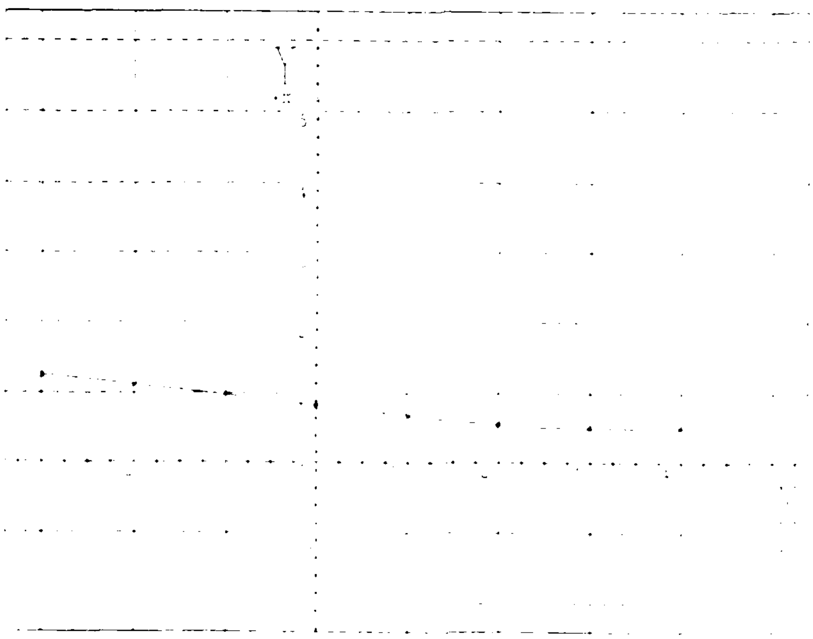


Figure 16. Target Trajectory Number Five.

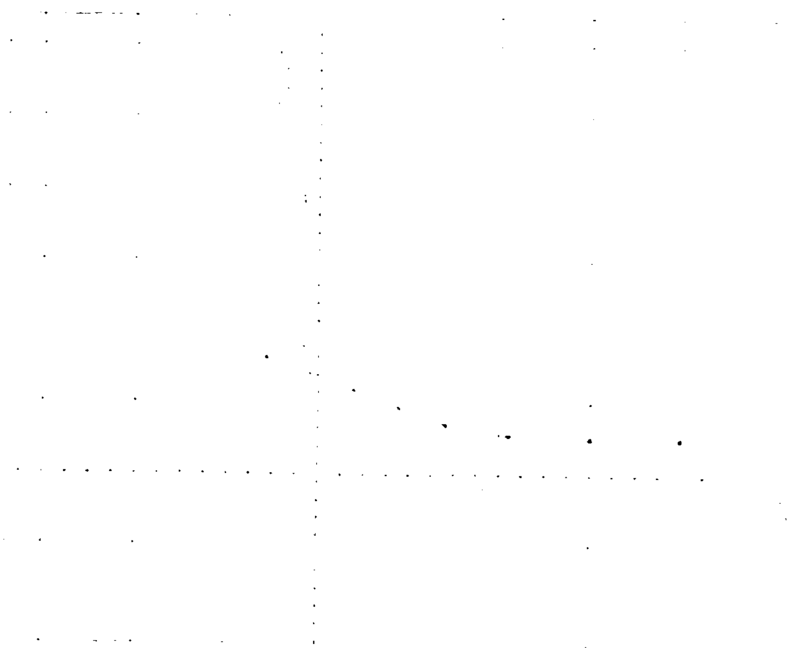


Figure 17. Target Trajectory Number Six.

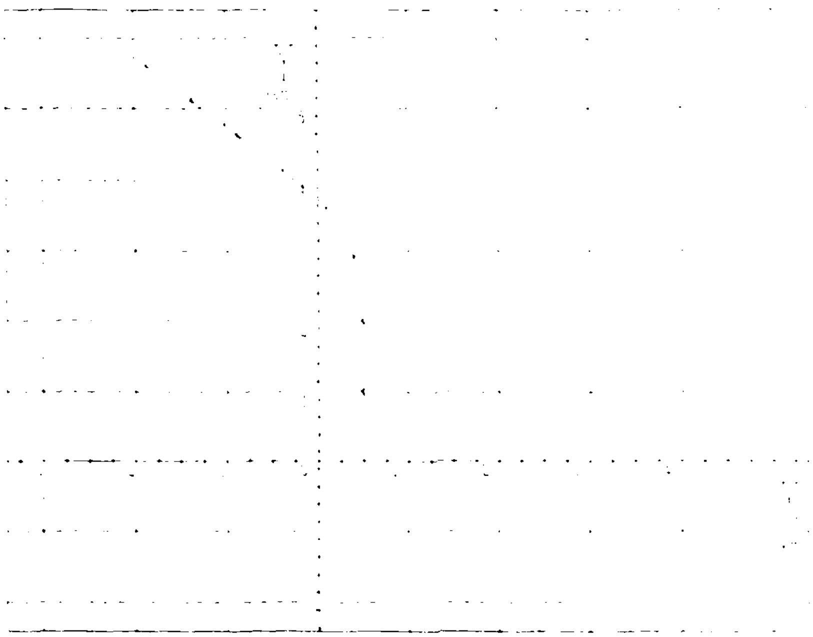


Figure 18. Target Trajectory Number Seven.

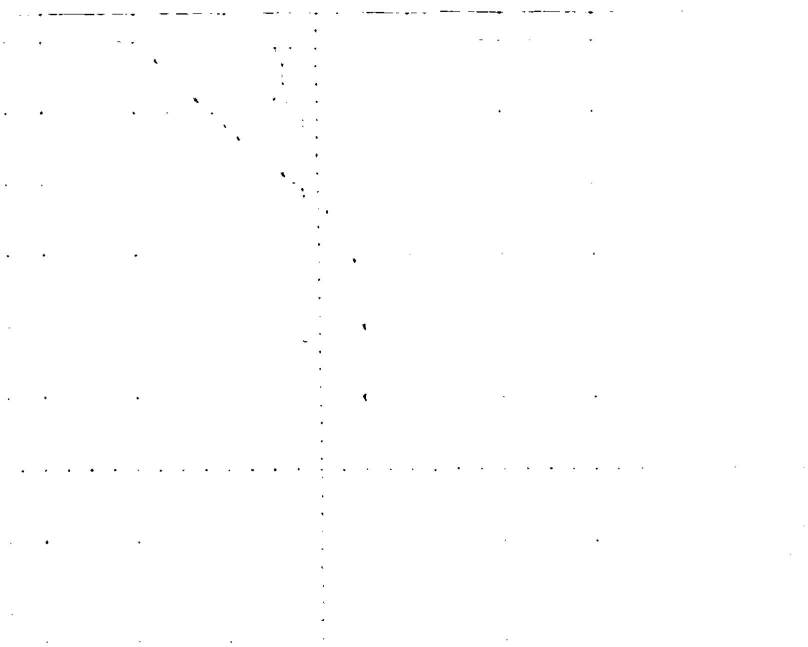


Figure 19. Target Trajectory Number Eight.

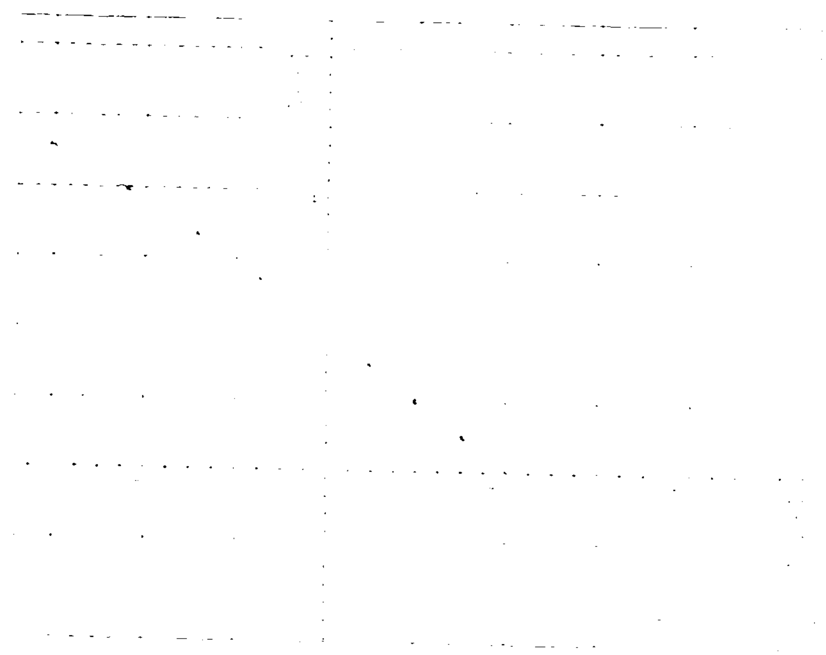
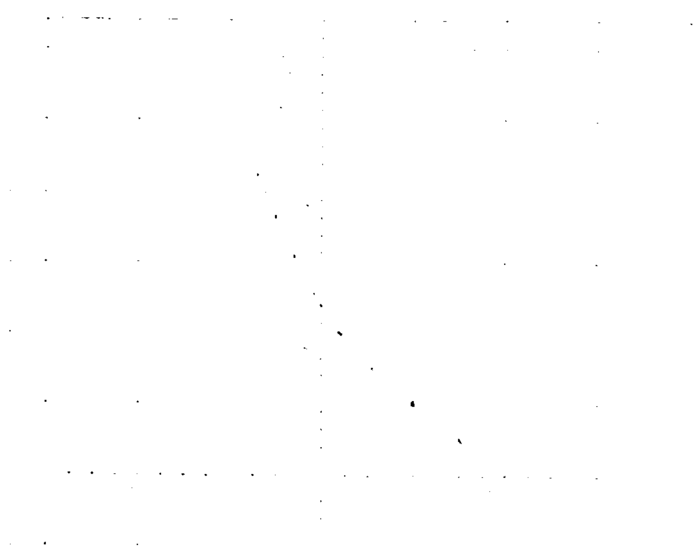


Figure 20. Target Trajectory Number Nine.



[illegible]

Appendix B. *Multiple Kalman Filter Residual Plots.*

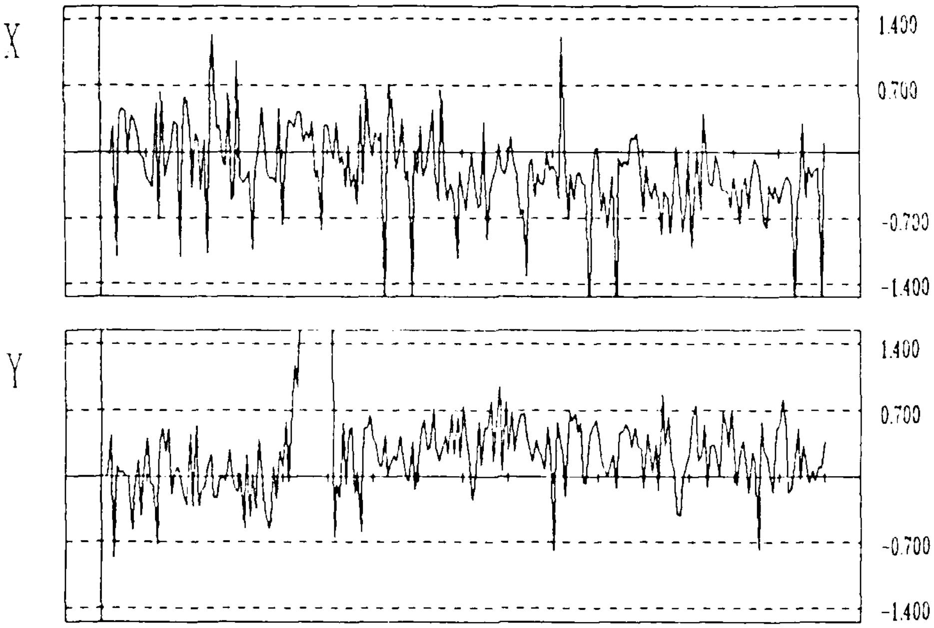


Figure 22. Kalman Filter Number One Residual Plot from Trajectory Two.

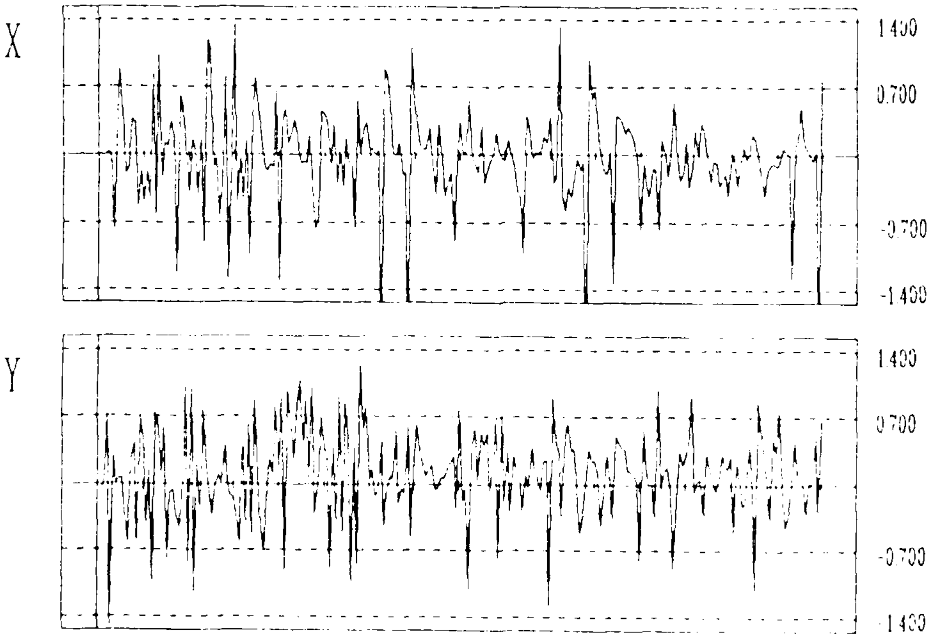


Figure 23. Kalman Filter Number Two Residual Plot from Trajectory Two.

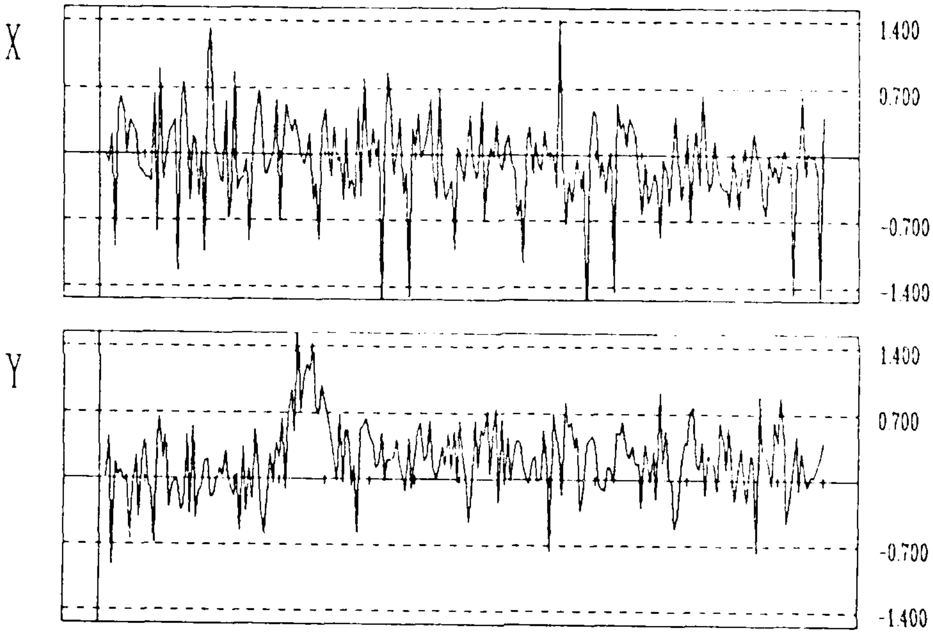


Figure 24. Kalman Filter Number Three Residual Plot from Trajectory Two.

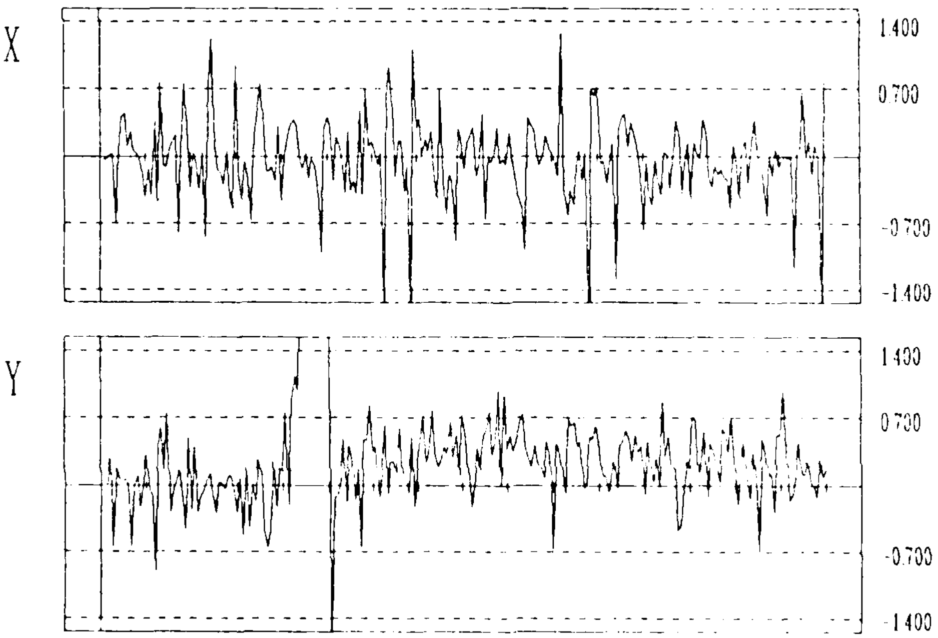


Figure 25. Kalman Filter Number Four Residual Plot from Trajectory Two.

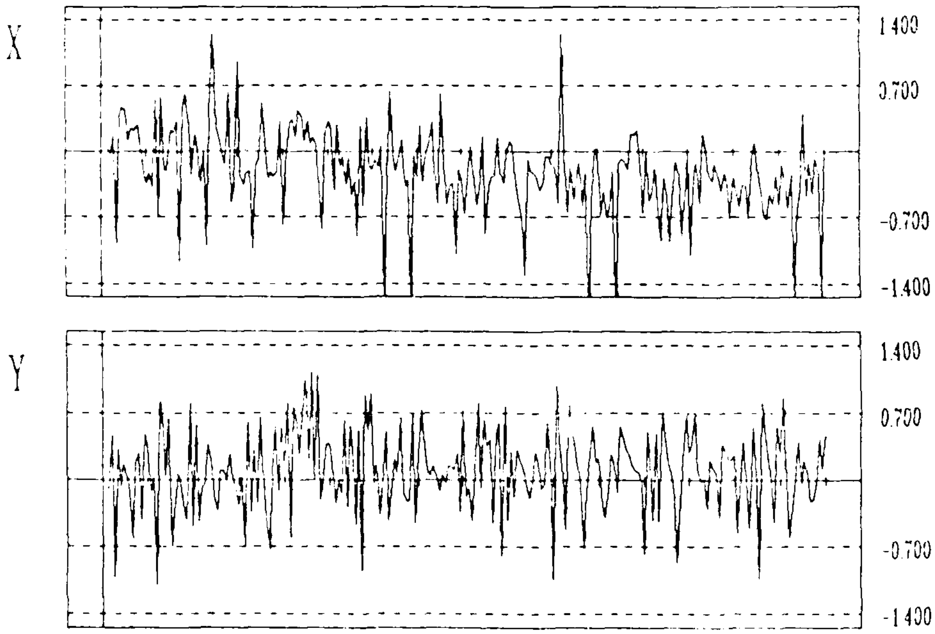


Figure 26. Kalman Filter Number Five Residual Plot from Trajectory Two.

Appendix C. *Kalman Filter Residual Statistics Plots for Trajectory Two.*

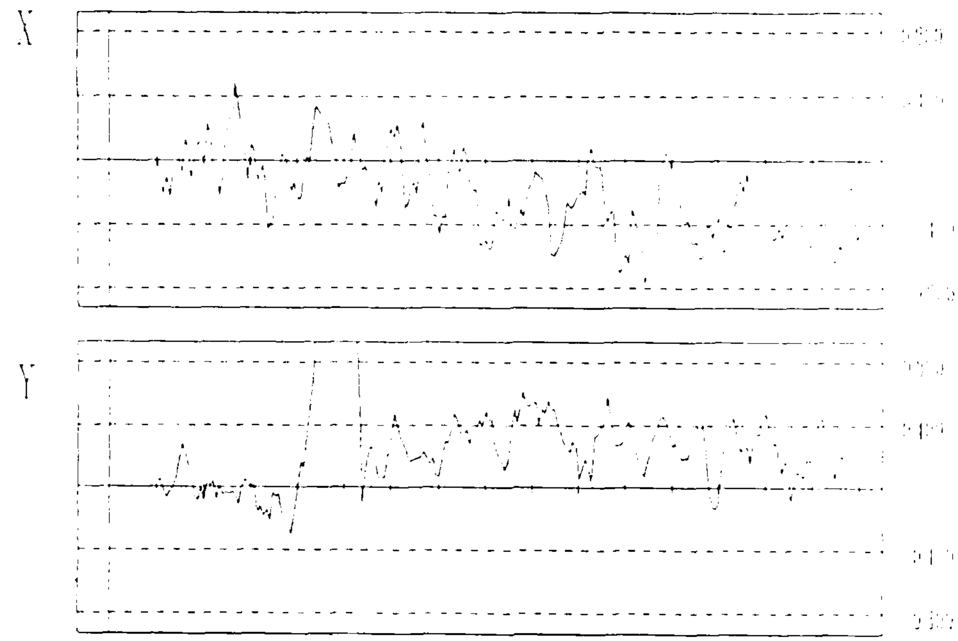


Figure 27. Mean Statistic of Filter Number One Residuals from Trajectory Two.

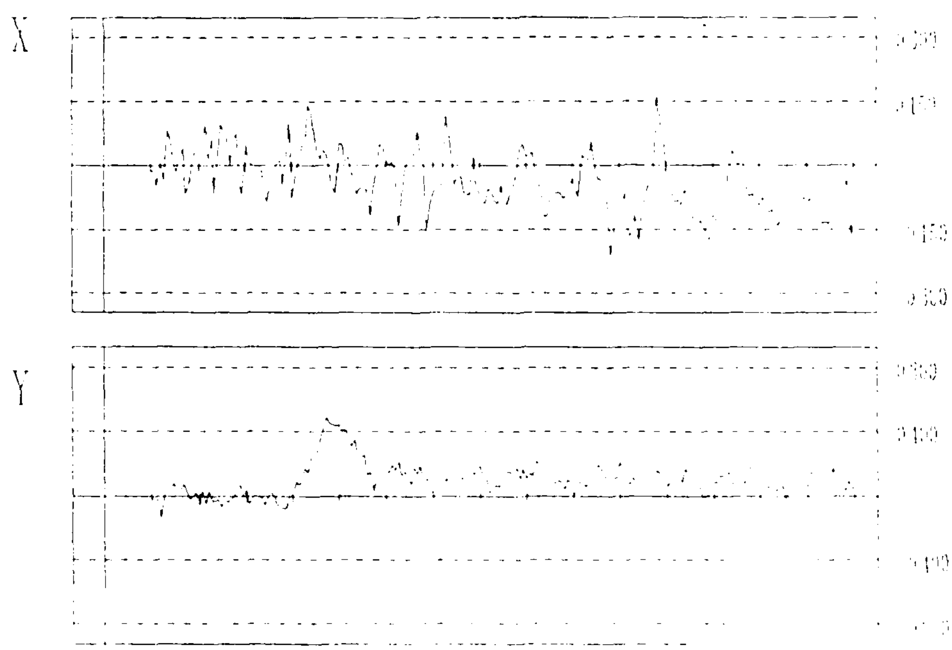


Figure 28. Mean Statistic of Filter Number Two Residuals from Trajectory Two.

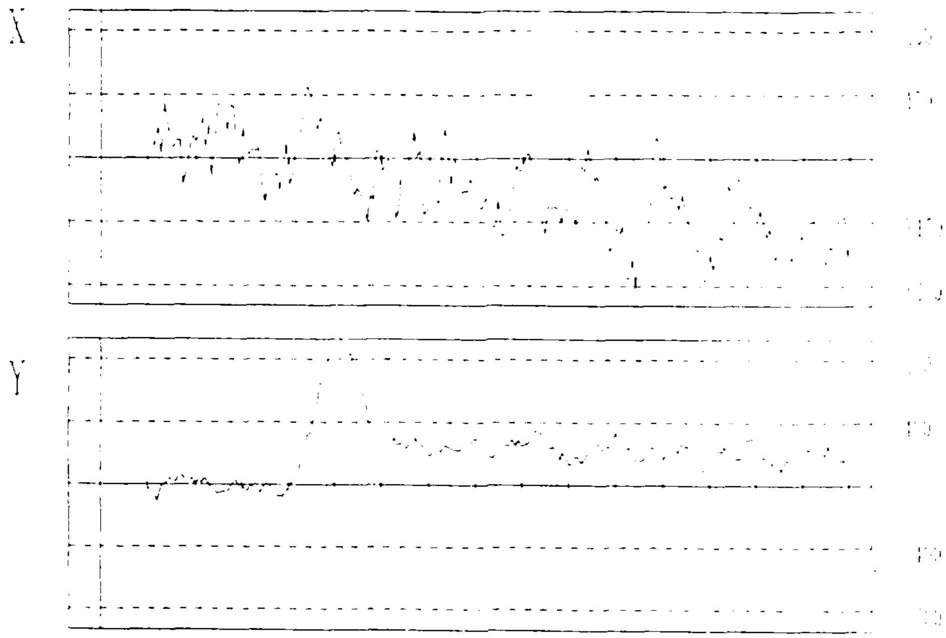


Figure 29. Mean Statistic of Filter Number Three Residuals from Trajectory Two.

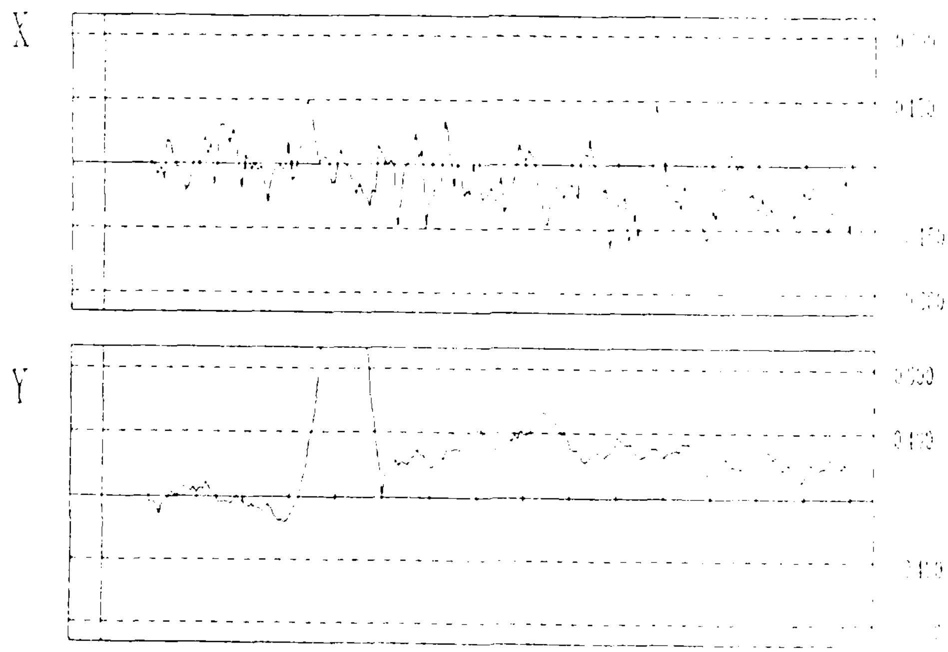


Figure 30. Mean Statistic of Filter Number Four Residuals from Trajectory Two.

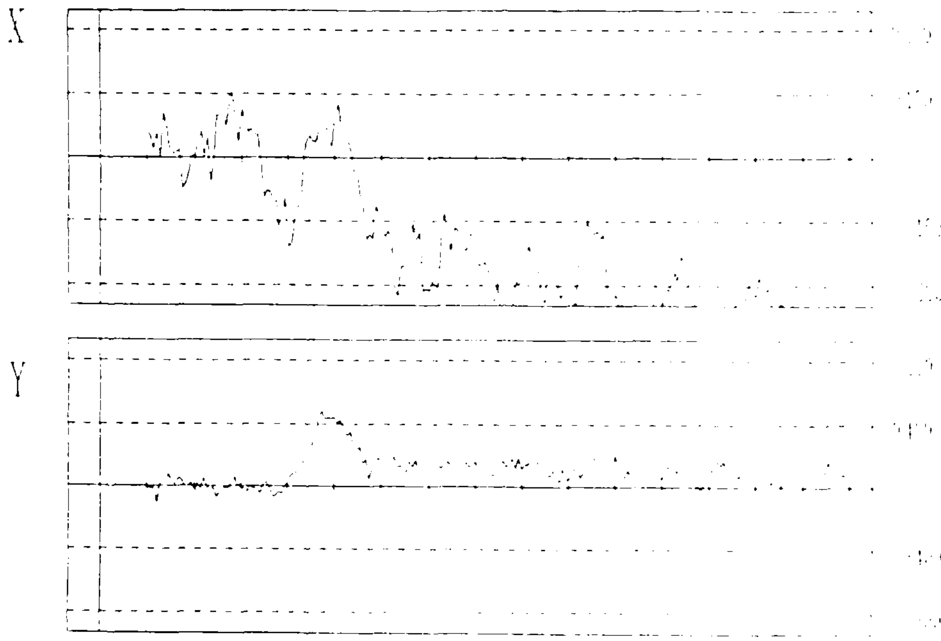


Figure 31. Mean Statistic of Filter Number Five Residuals from Trajectory Two

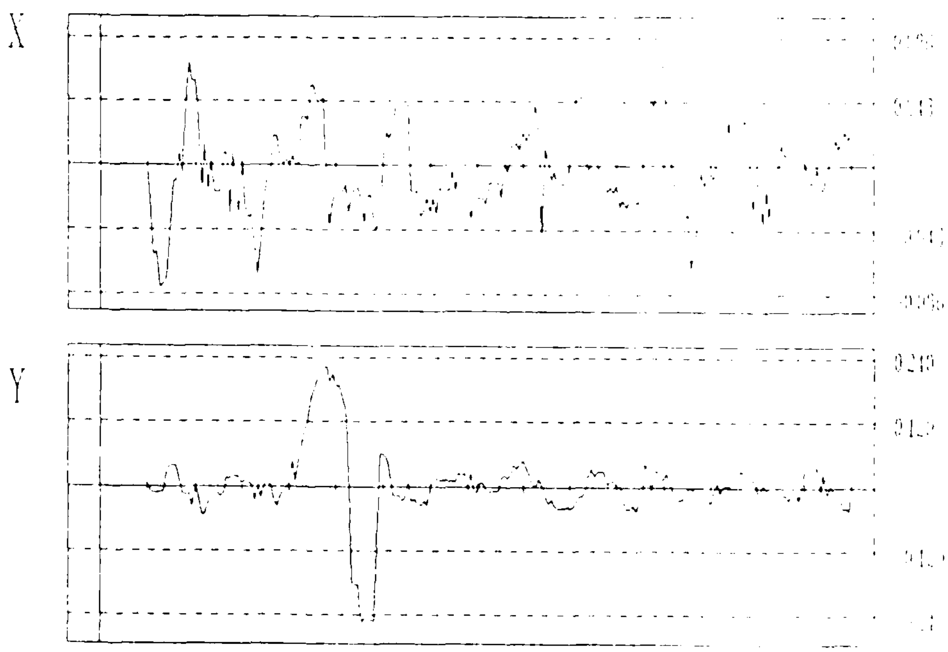


Figure 32. Slope Statistic of Filter Number One Residuals from Trajectory Two.

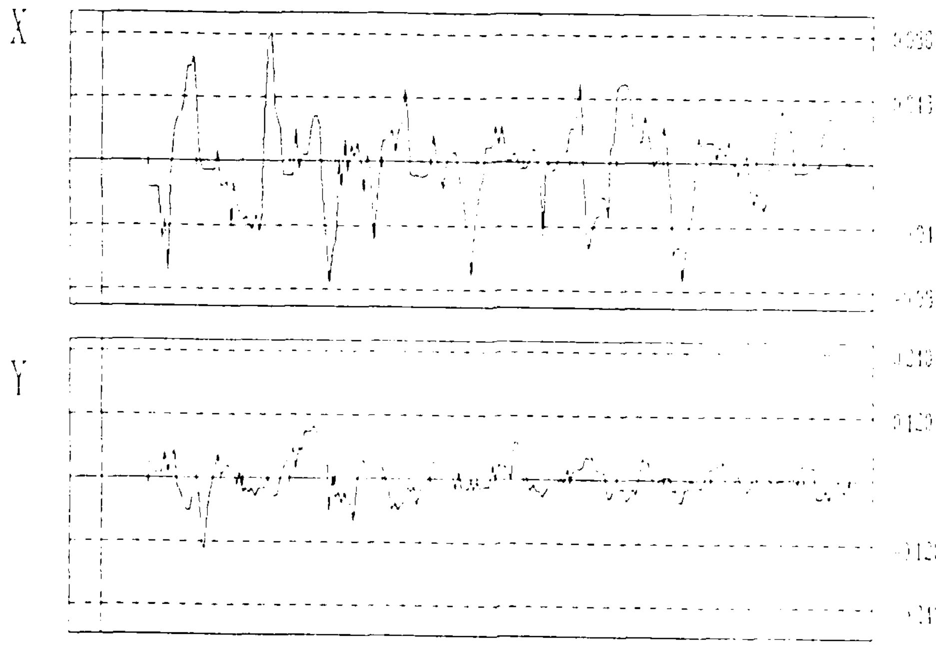


Figure 33. Slope Statistic of Filter Number Two Residuals from Trajectory Two.

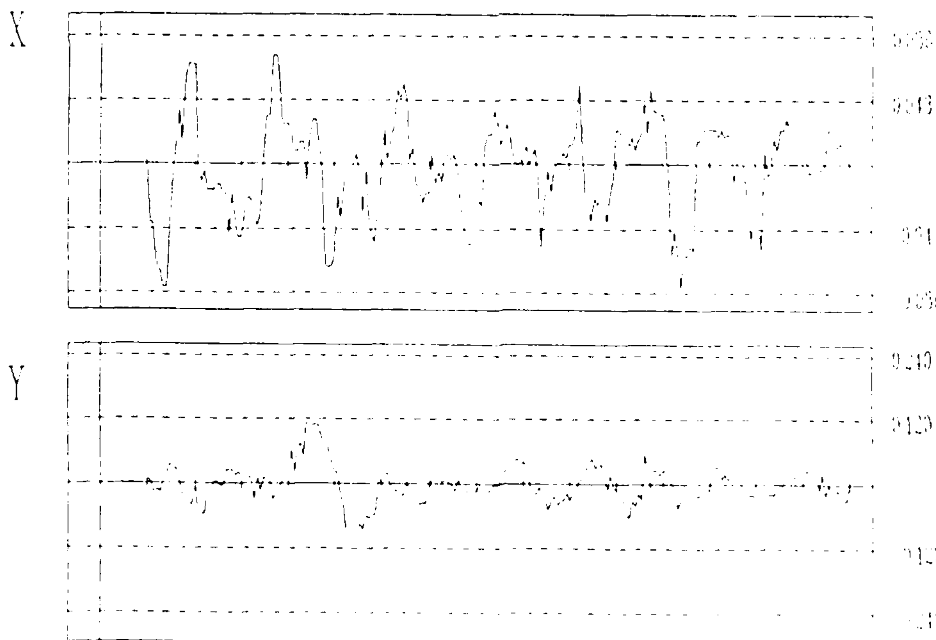


Figure 34. Slope Statistic of Filter Number Three Residuals from Trajectory Two.

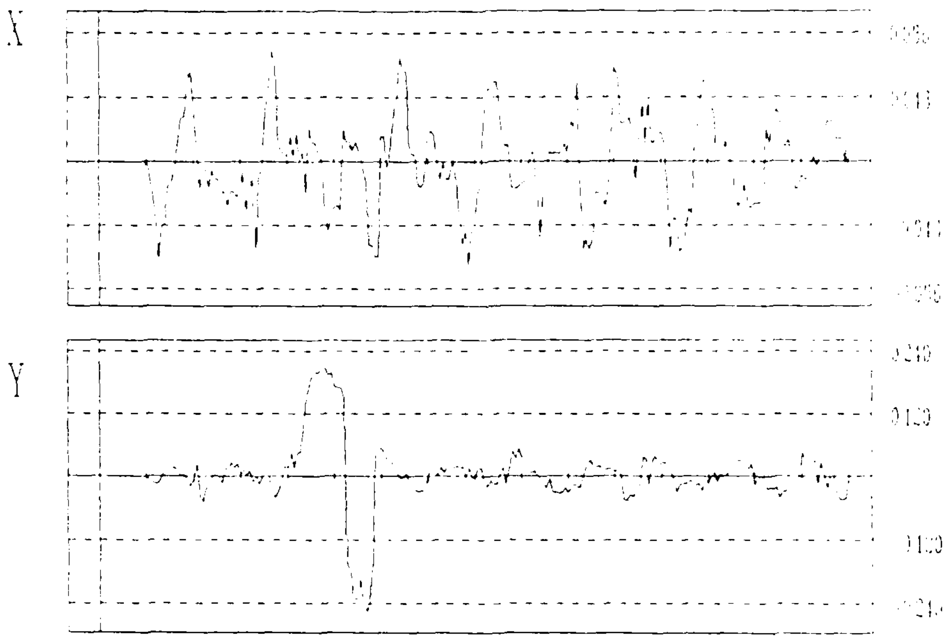


Figure 35. Slope Statistic of Filter Number Four Residuals from Trajectory Two

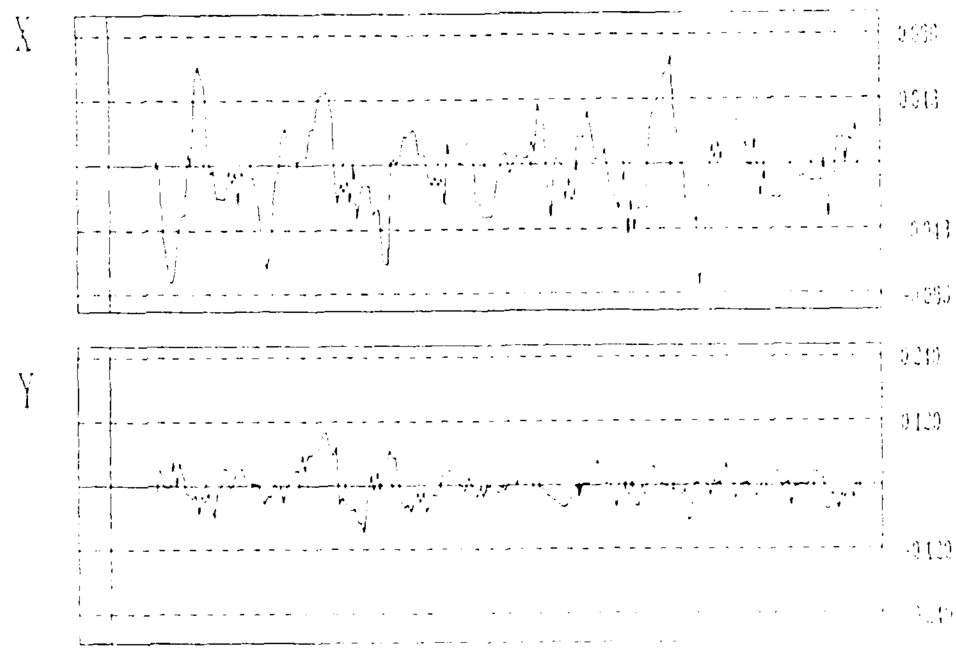


Figure 36. Slope Statistic of Filter Number Five Residuals from Trajectory Two.

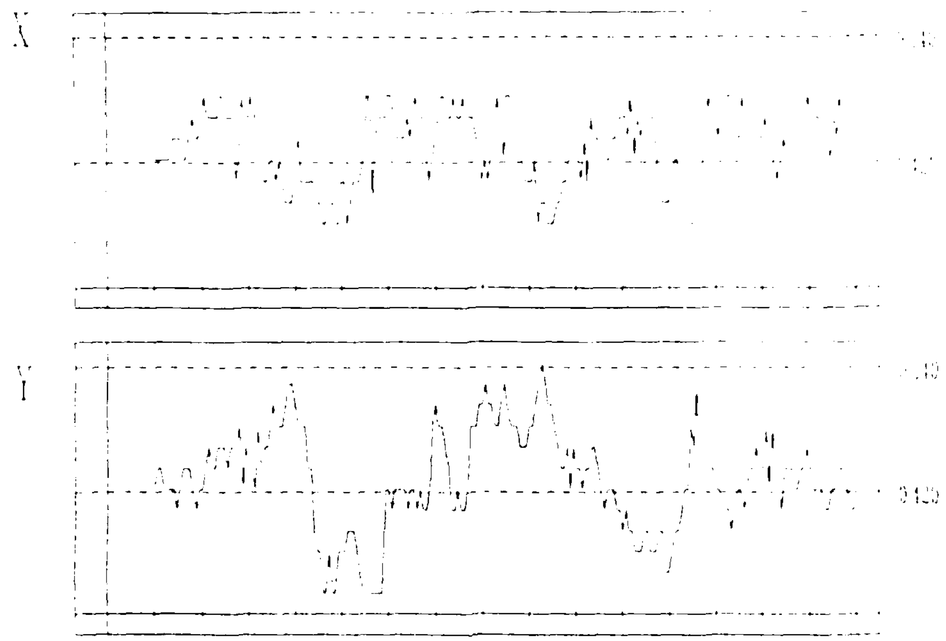


Figure 37. Percent Mean Crossing Statistic of Filter Number One Residuals from Trajectory Two.

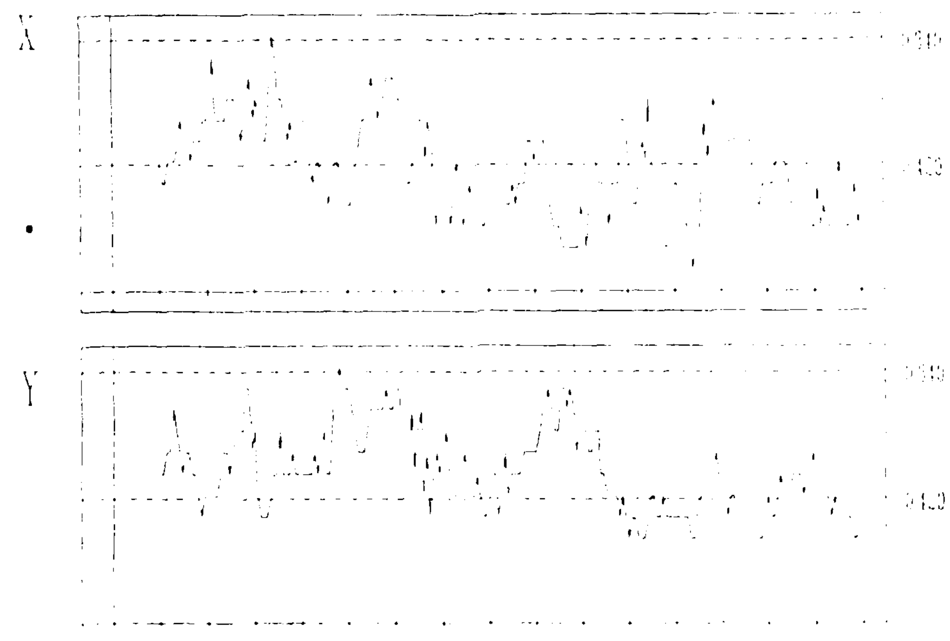


Figure 38. Percent Mean Crossing Statistic of Filter Number Two Residuals from Trajectory Two.

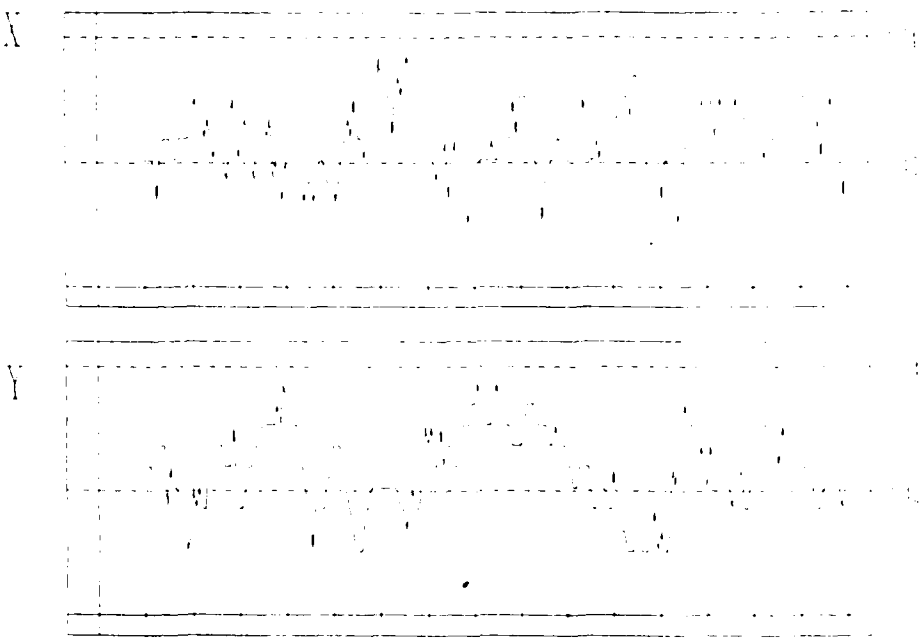


Figure 39. Percent Mean Crossing Statistic of Filter Number Three Residuals from Trajectory Two.

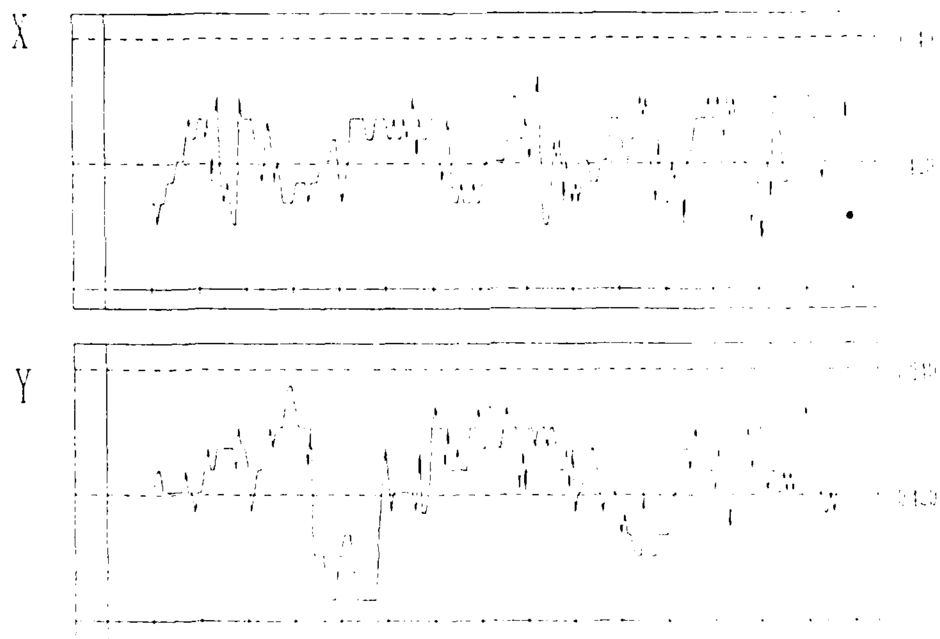


Figure 40. Percent Mean Crossing Statistic of Filter Number Four Residuals from Trajectory Two.

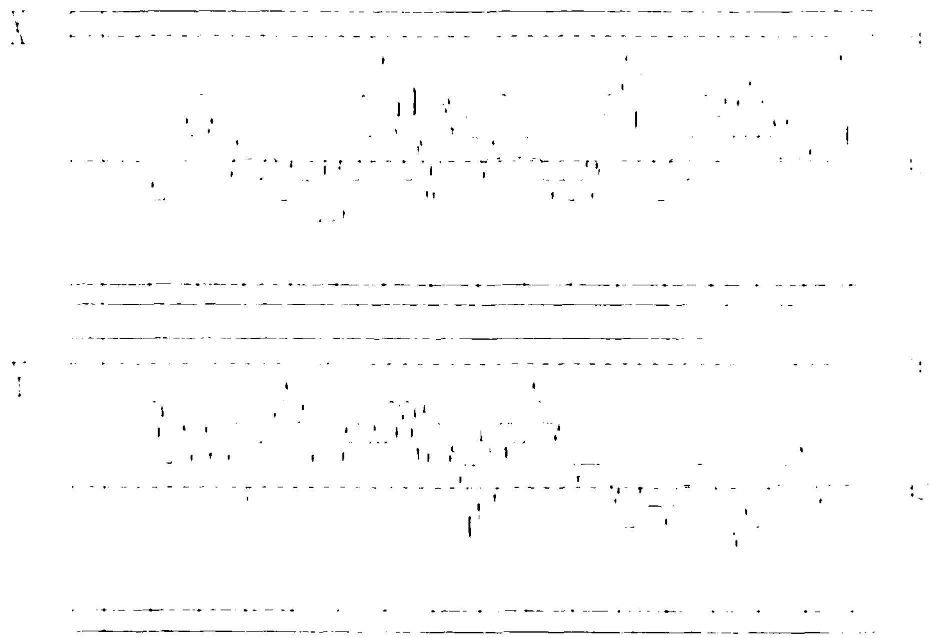


Figure 41. Percent Mean Crossing Statistic of Filter Number Five Residuals from Trajectory Two

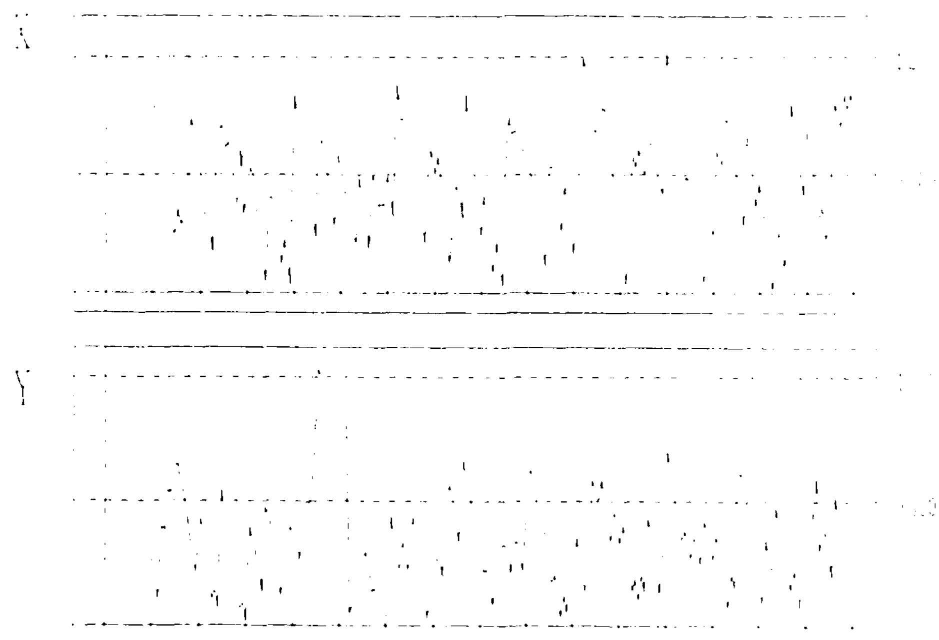


Figure 42. Probability Gaussian Statistic of Filter Number One Residuals from Trajectory Two.

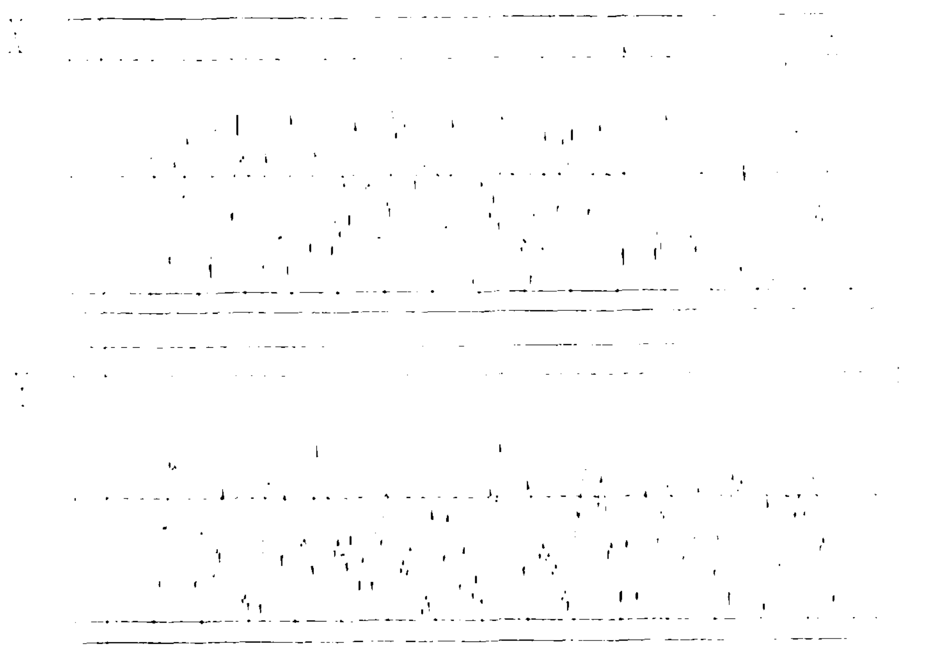


Figure 43. Probability Gaussian Statistic of Filter Number Two Residuals from Trajectory Two.

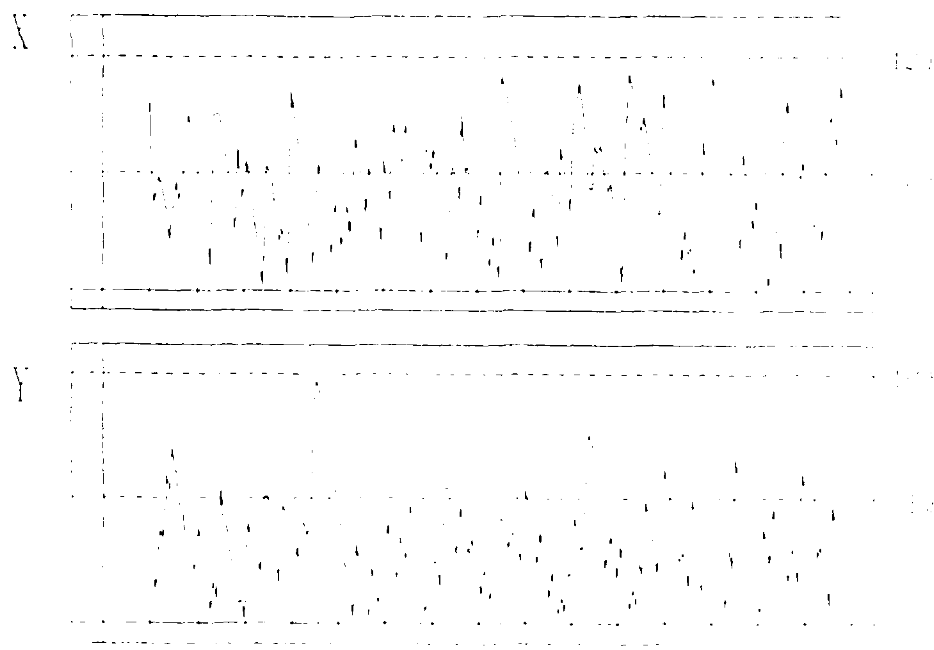


Figure 44. Probability Gaussian Statistic of Filter Number Three Residuals from Trajectory Two.

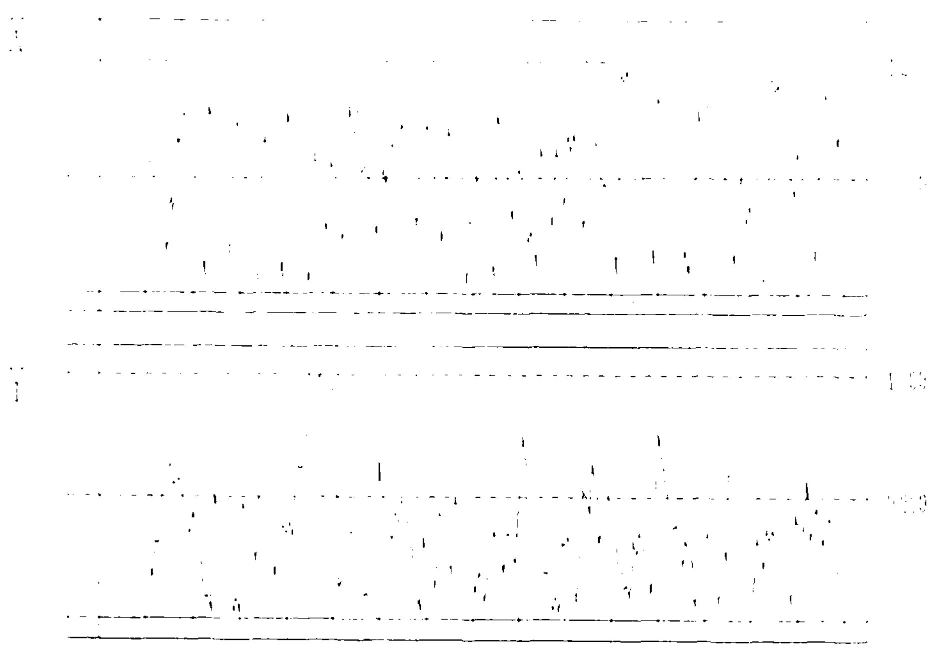


Figure 45. Probability Gaussian Statistic of Filter Number Four Residuals from Trajectory Two.

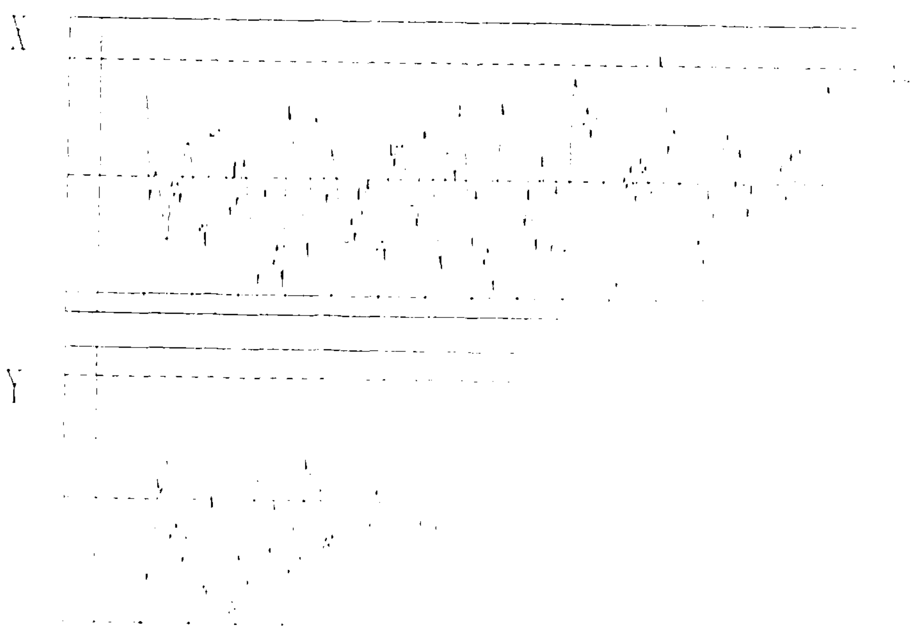
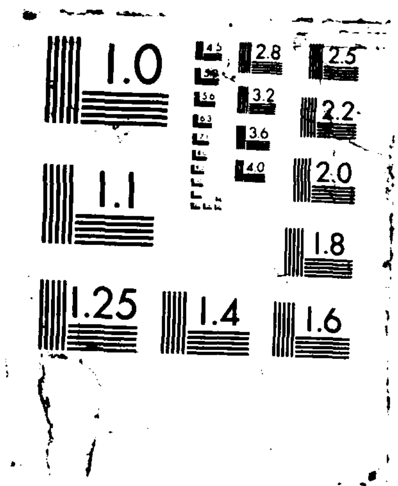


Figure 46. P

AD-A190 520 KALMAN FILTER RESIDUAL EXPERT SYSTEM(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF ENGINEERING J D GRIMSHAW DEC 87 AFIT/GCE/ENG/87D-4 2/2

UNCLASSIFIED F/G 12/5 NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

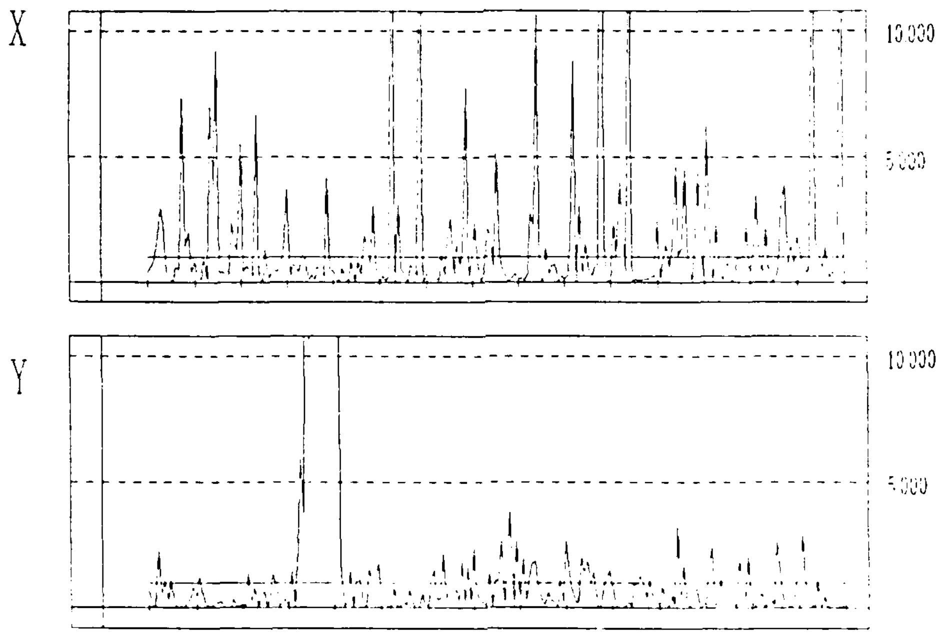


Figure 47. Scaled Residual Statistic of Filter Number One Residuals from Trajectory Two.

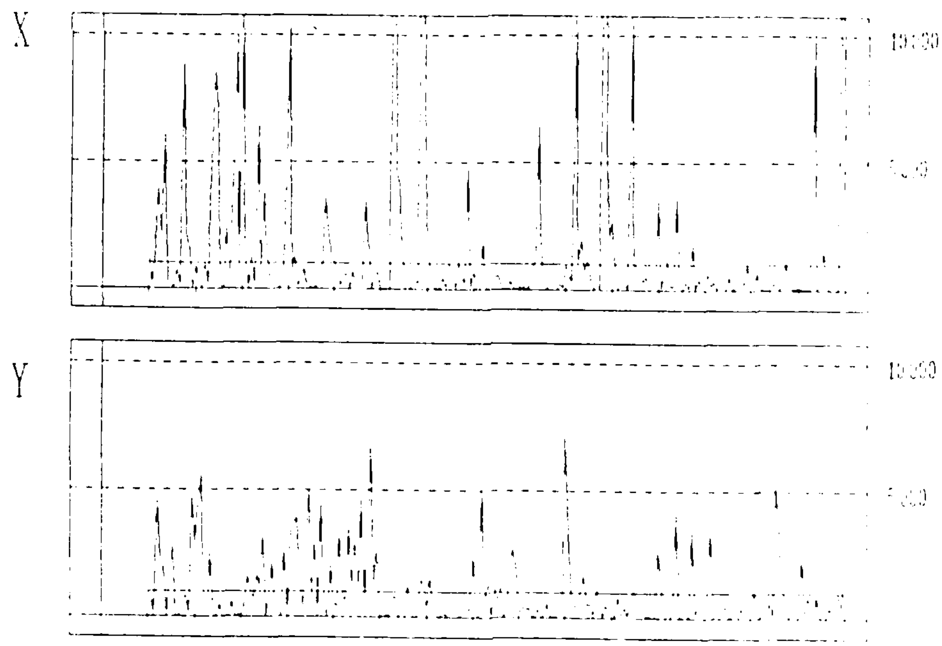


Figure 48. Scaled Residual Statistic of Filter Number Two Residuals from Trajectory Two.

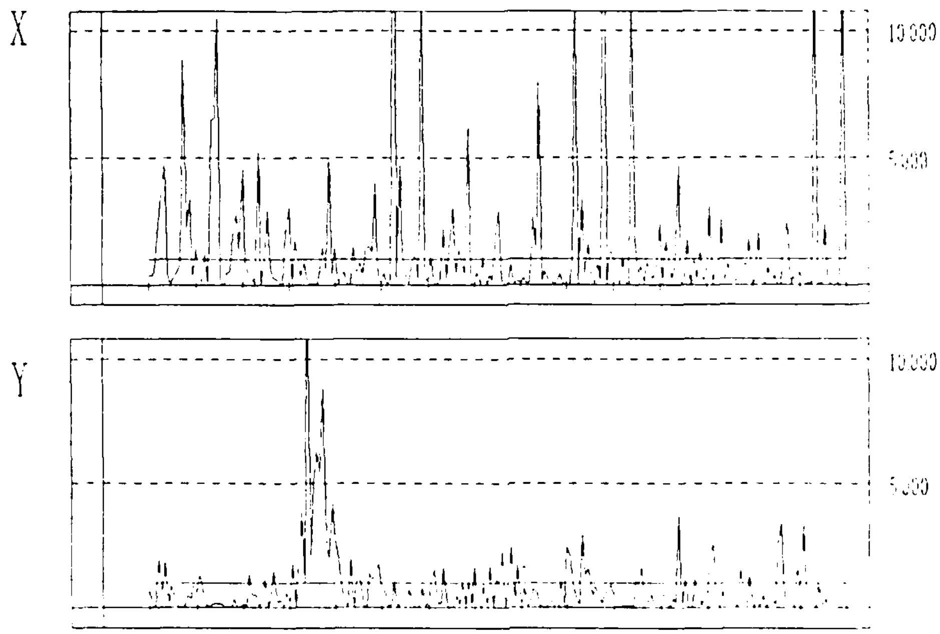


Figure 49. Scaled Residual Statistic of Filter Number Three Residuals from Trajectory Two.

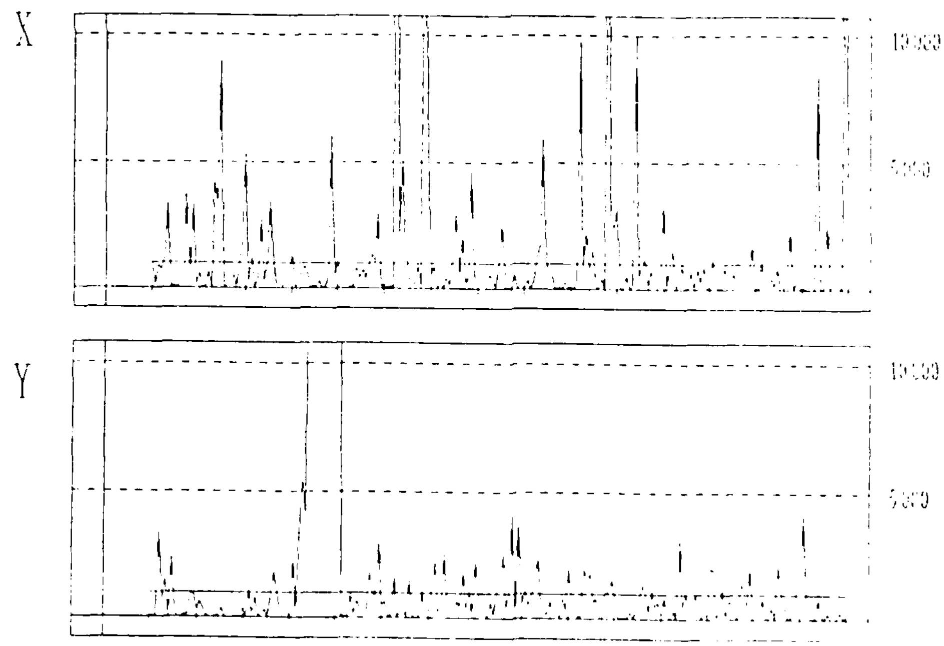


Figure 50. Scaled Residual Statistic of Filter Number Four Residuals from Trajectory Two.

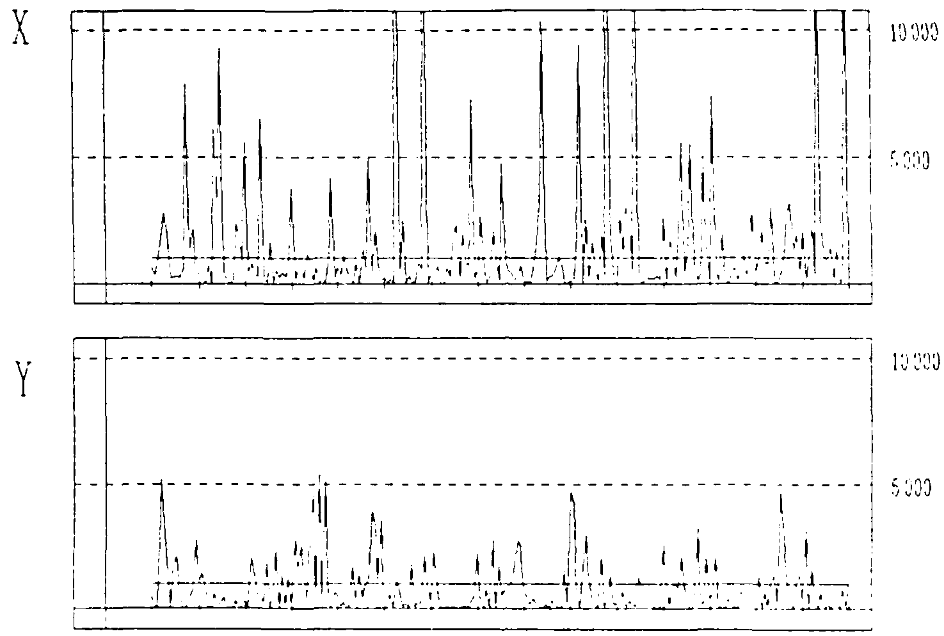


Figure 51. Scaled Residual Statistic of Filter Number Five Residuals from Trajectory Two.

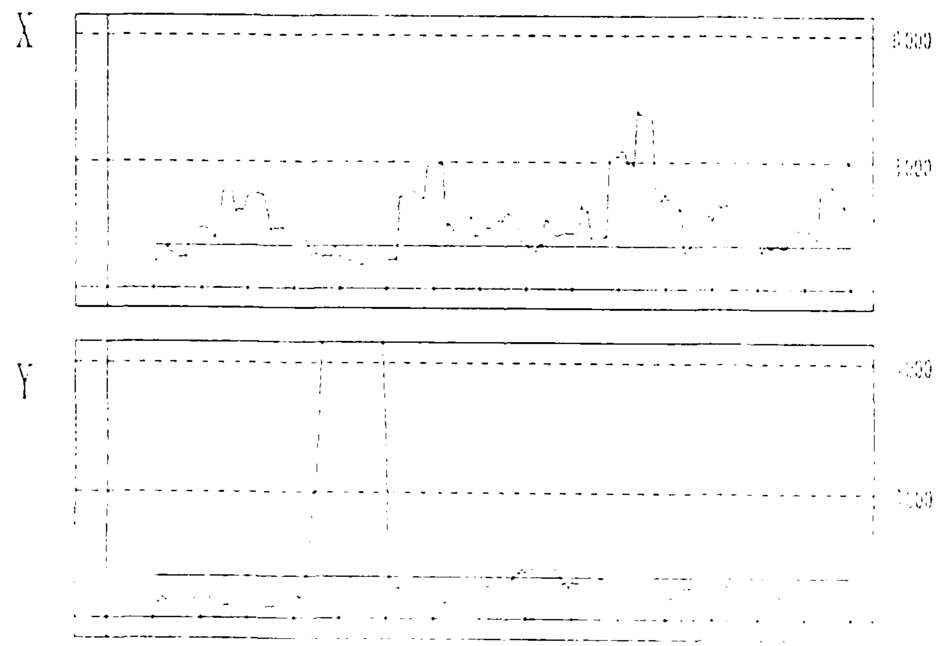


Figure 52. Average Scaled Residual Statistic of Filter Number One Residuals from Trajectory Two.

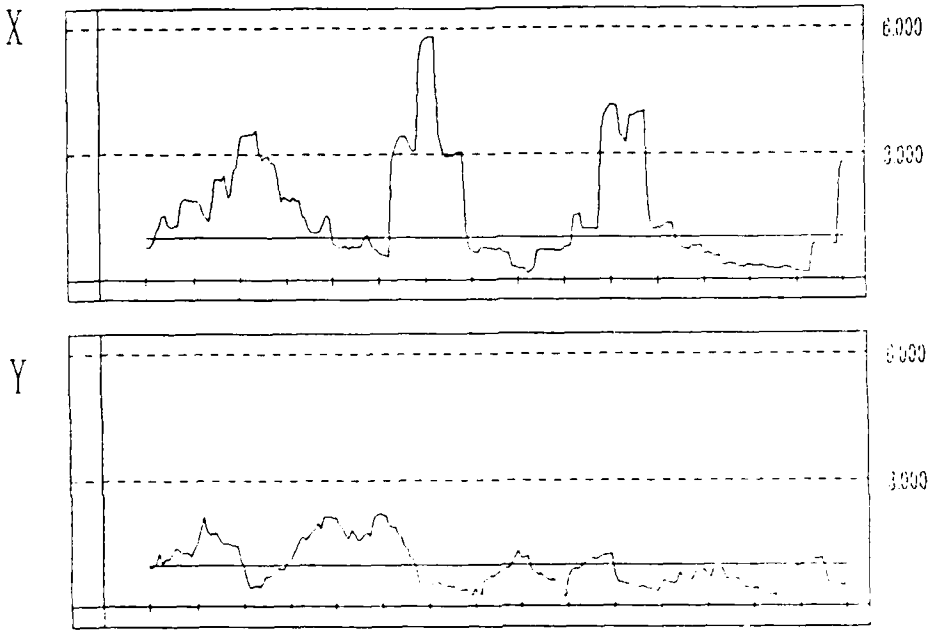


Figure 53. Average Scaled Residual Statistic of Filter Number Two Residuals from Trajectory Two.

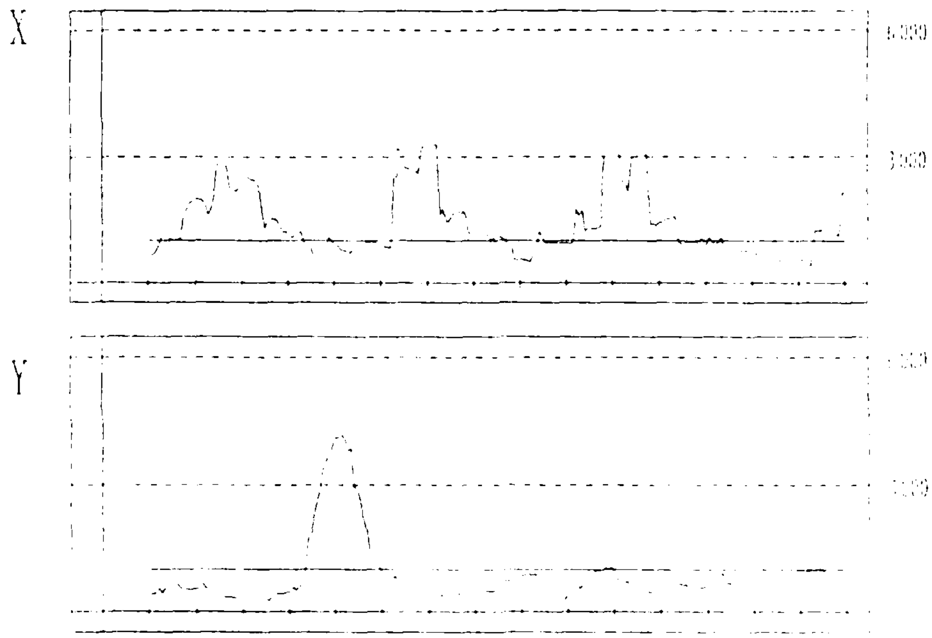


Figure 54. Average Scaled Residual Statistic of Filter Number Three Residuals from Trajectory Two.

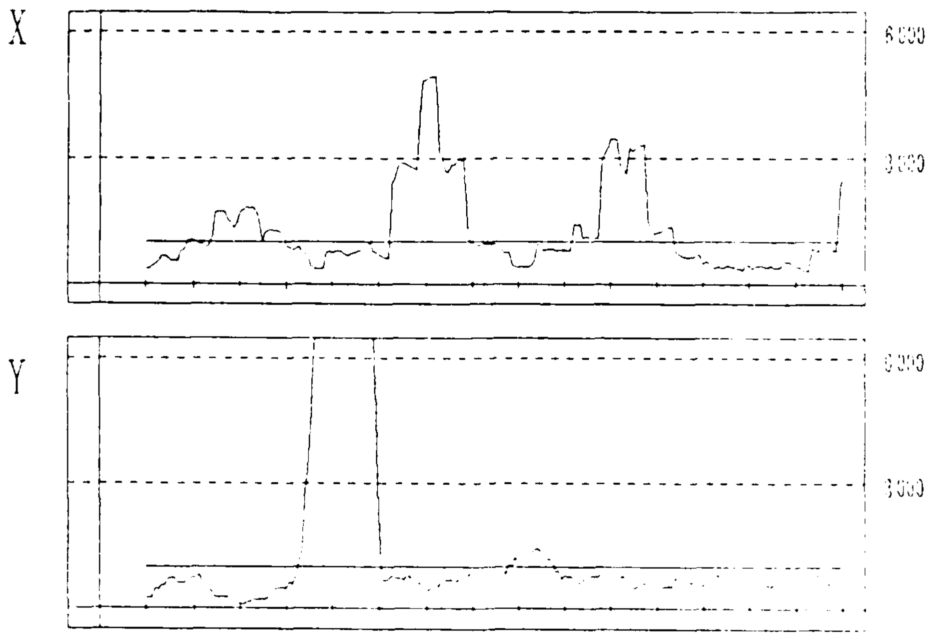


Figure 55. Average Scaled Residual Statistic of Filter Number Four Residuals from Trajectory Two.

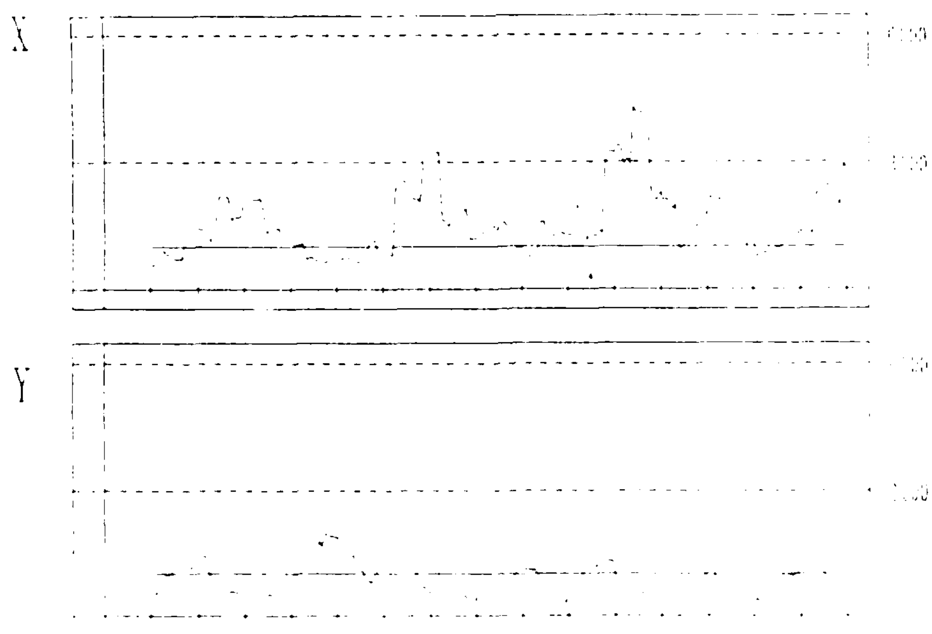


Figure 56. Average Scaled Residual Statistic of Filter Number Five Residuals from Trajectory Two.

Appendix D. *Kalman Filter Residual Probabilities Plots.*

Figure 57. Residual Probabilities from Trajectory One.

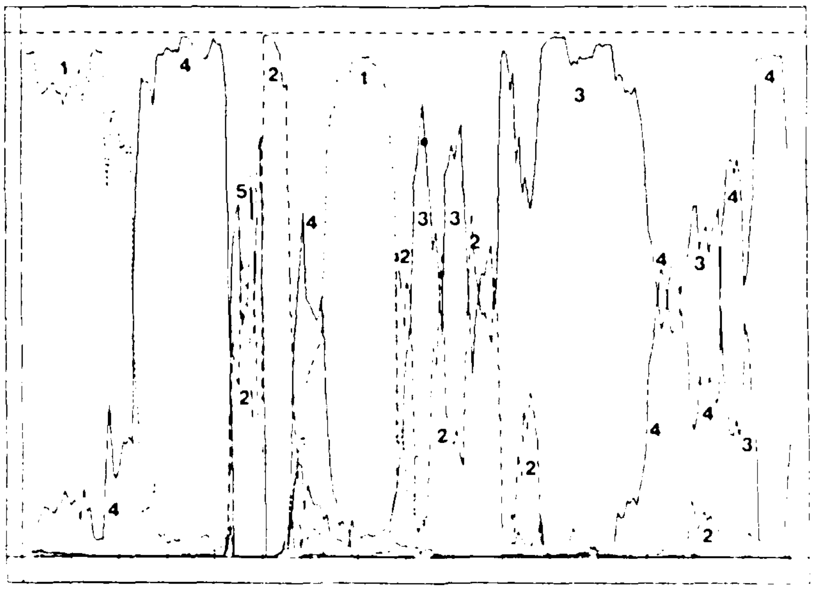


Figure 58. Residual Probabilities from Trajectory Two.

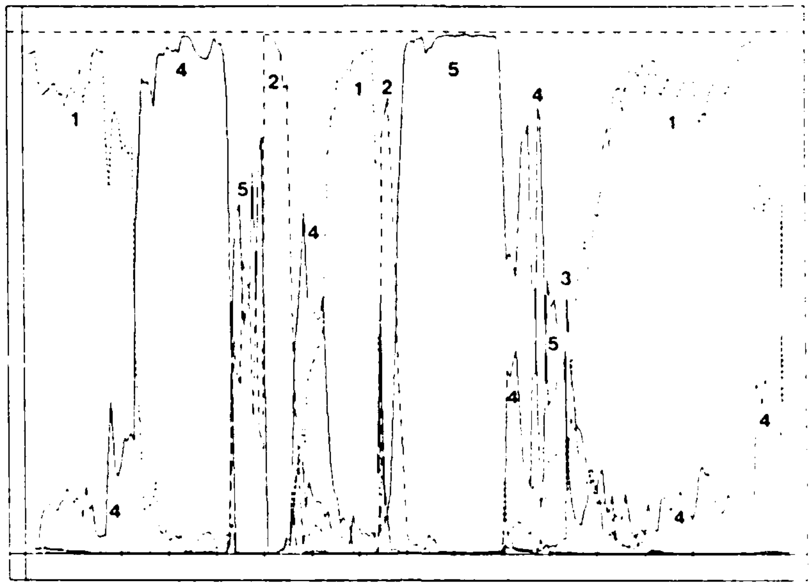


Figure 59. Residual Probabilities from Trajectory Three.

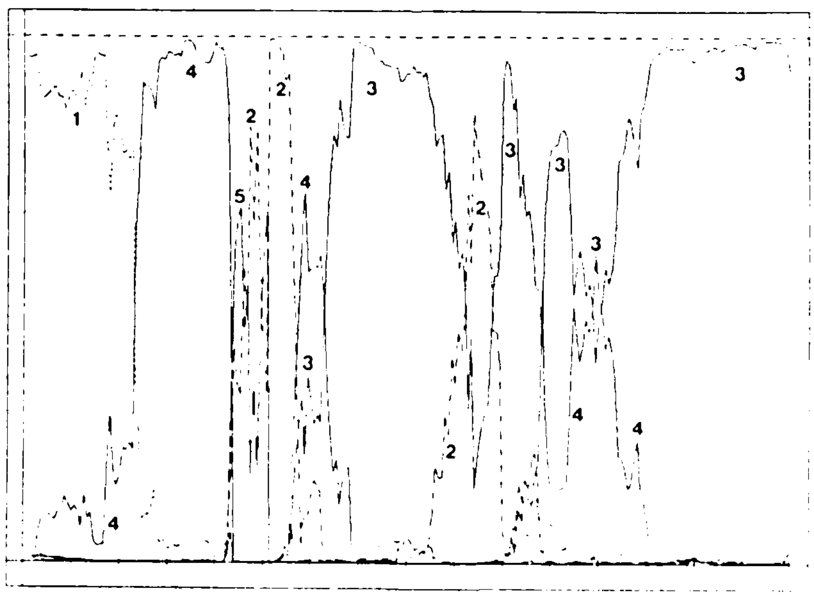


Figure 60. Residual Probabilities from Trajectory Four.

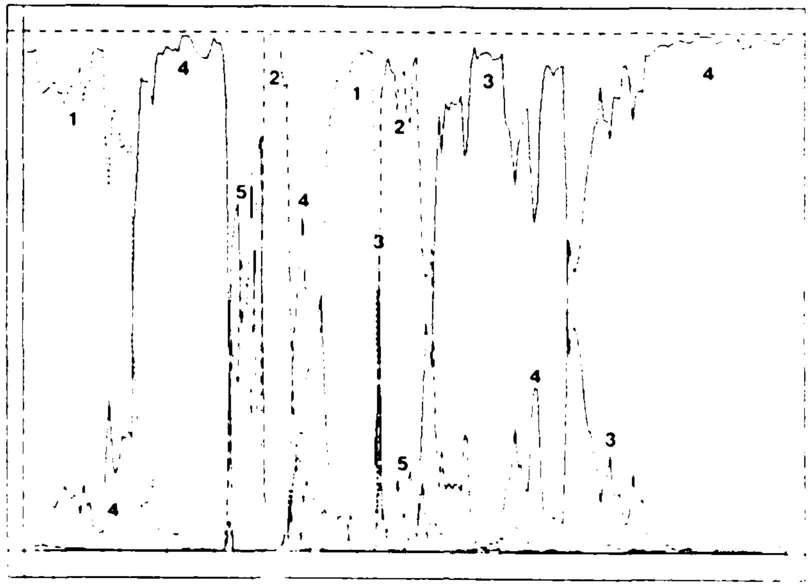


Figure 61. Residual Probabilities from Trajectory Five.

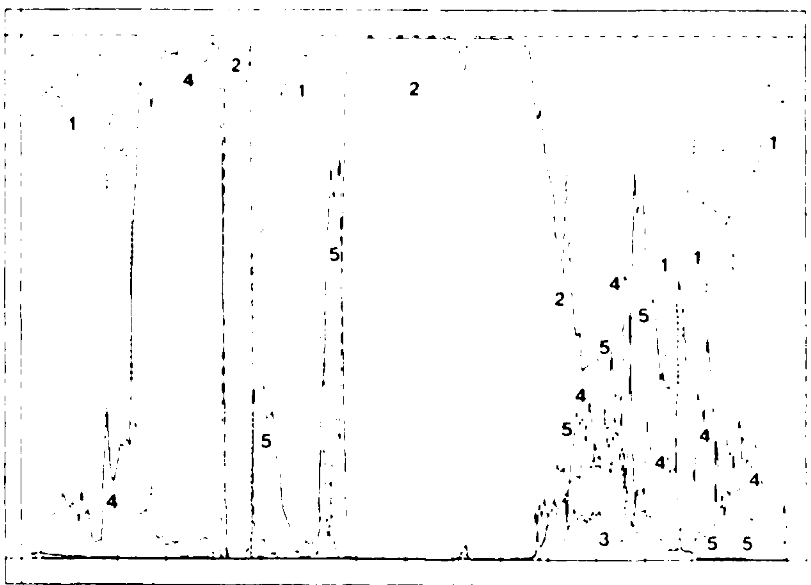


Figure 62. Residual Probabilities from Trajectory Six.

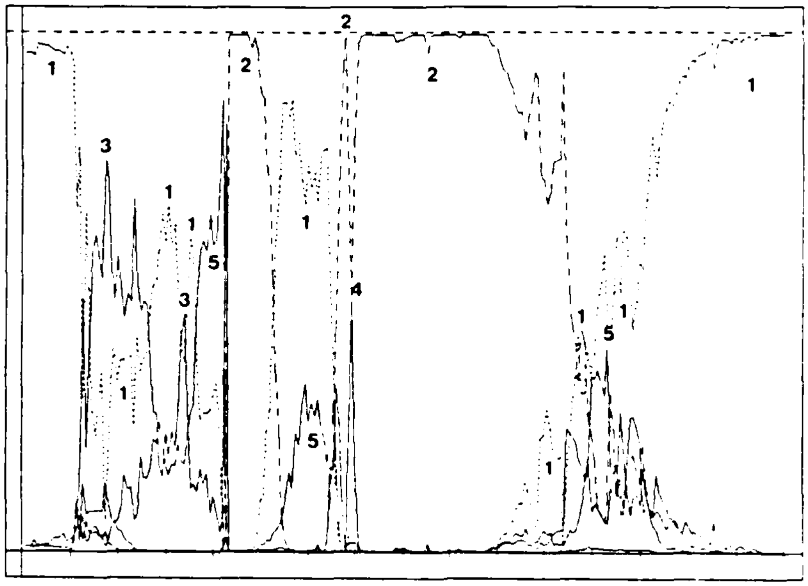


Figure 63. Residual Probabilities from Trajectory Seven.

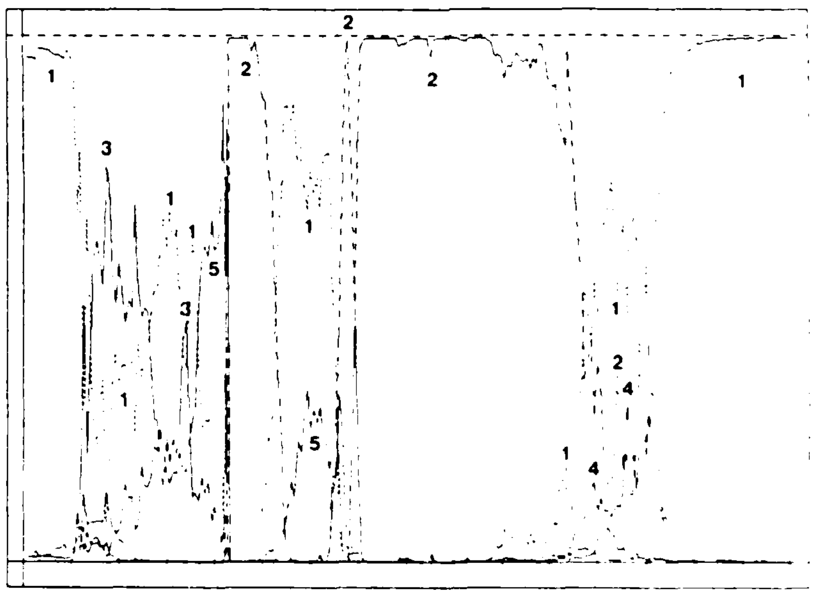


Figure 64. Residual Probabilities from Trajectory Eight.

Figure 65. Residual Probabilities from Trajectory Nine.

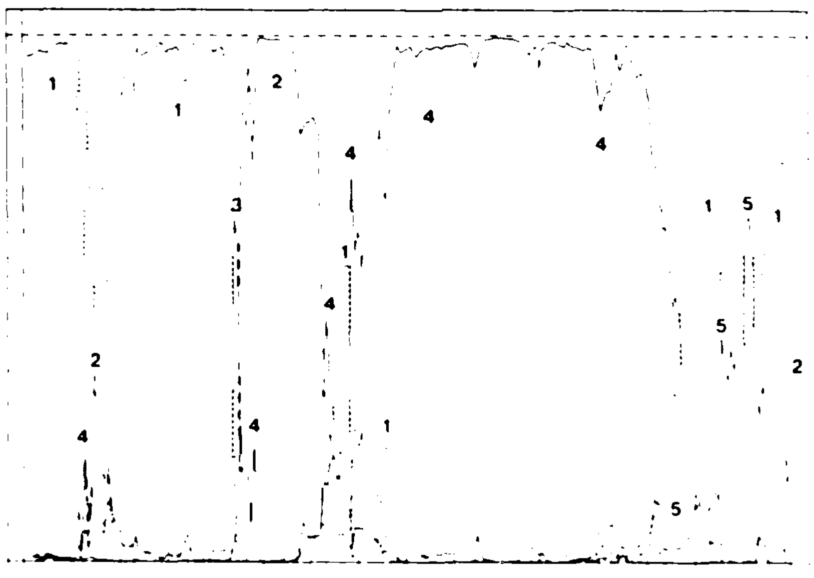


Figure 66. Residual Probabilities from Trajectory Ten.

Appendix E. *KREST Results*

E.1 KREST Results from Trajectory One Residuals.

KREST: Kalman filter Expert SysTem.
NFRMS: 240
ITraj: 1

#	Rule	KR	MAP	P1	P2	P3	P4	P5
1		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
2		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
3		1	1	0.9605	0.0092	0.0100	0.0103	0.0099
4		1	1	0.9644	0.0014	0.0091	0.0178	0.0073
5		1	1	0.9046	0.0040	0.0140	0.0676	0.0098
6		1	1	0.8829	0.0051	0.0122	0.0900	0.0099
7		1	1	0.8849	0.0014	0.0082	0.0967	0.0087
8		1	1	0.8909	0.0013	0.0079	0.0918	0.0081
9		1	1	0.9001	0.0010	0.0077	0.0841	0.0071
10		1	1	0.9025	0.0013	0.0068	0.0812	0.0082
11		1	1	0.8835	0.0010	0.0070	0.1001	0.0084
12		1	1	0.8835	0.0010	0.0059	0.1036	0.0060
13		1	1	0.8625	0.0010	0.0053	0.1255	0.0057
14		1	1	0.8797	0.0010	0.0040	0.1121	0.0032
15		1	1	0.8957	0.0010	0.0039	0.0964	0.0030
16		1	1	0.8840	0.0010	0.0038	0.1083	0.0029
17		1	1	0.8948	0.0010	0.0039	0.0979	0.0024
18		1	1	0.9270	0.0010	0.0039	0.0672	0.0010
19		1	1	0.8661	0.0010	0.0025	0.1294	0.0010
20		1	1	0.9143	0.0010	0.0010	0.0827	0.0010
21		1	1	0.9020	0.0010	0.0010	0.0949	0.0011
22		1	1	0.9586	0.0010	0.0012	0.0383	0.0010
23		1	1	0.9668	0.0010	0.0010	0.0302	0.0010
24		1	1	0.9636	0.0010	0.0010	0.0334	0.0010
25		1	1	0.9634	0.0010	0.0010	0.0336	0.0010
26		1	1	0.7833	0.0010	0.0010	0.2137	0.0010
27		1	1	0.7072	0.0010	0.0010	0.2898	0.0010
28		1	1	0.8328	0.0017	0.0010	0.1635	0.0010
29		1	1	0.8499	0.0010	0.0010	0.1471	0.0010
30		1	1	0.8297	0.0010	0.0010	0.1673	0.0010
31		1	1	0.7769	0.0010	0.0010	0.2201	0.0010
32		1	1	0.7838	0.0010	0.0010	0.2132	0.0010
33		1	1	0.7676	0.0010	0.0010	0.2294	0.0010
34		1	1	0.7818	0.0010	0.0010	0.2152	0.0010
35	65	1	4	0.3677	0.0010	0.0010	0.6293	0.0010

36	4	4	0.2524	0.0010	0.0010	0.7446	0.0010
37	4	4	0.0835	0.0021	0.0010	0.9124	0.0010
38	4	4	0.0918	0.0018	0.0012	0.9043	0.0010
39	4	4	0.0903	0.0016	0.0012	0.9059	0.0010
40	4	4	0.1073	0.0010	0.0010	0.8896	0.0010
41	4	4	0.1377	0.0010	0.0010	0.8592	0.0011
42	4	4	0.0449	0.0010	0.0010	0.9521	0.0010
43	4	4	0.0366	0.0010	0.0010	0.9604	0.0010
44	4	4	0.0422	0.0011	0.0010	0.9544	0.0012
45	4	4	0.0261	0.0010	0.0013	0.9707	0.0010
46	4	4	0.0267	0.0010	0.0010	0.9703	0.0010
47	4	4	0.0325	0.0014	0.0014	0.9637	0.0010
48	4	4	0.0286	0.0010	0.0010	0.9684	0.0010
49	4	4	0.0345	0.0011	0.0015	0.9616	0.0014
50	4	4	0.0040	0.0010	0.0010	0.9930	0.0010
51	4	4	0.0037	0.0010	0.0011	0.9932	0.0010
52	4	4	0.0052	0.0010	0.0010	0.9918	0.0010
53	4	4	0.0114	0.0018	0.0010	0.9842	0.0016
54	4	4	0.0242	0.0026	0.0016	0.9687	0.0029
55	4	4	0.0343	0.0026	0.0021	0.9585	0.0025
56	4	4	0.0365	0.0040	0.0035	0.9515	0.0044
57	4	4	0.0411	0.0036	0.0035	0.9496	0.0022
58	4	4	0.0393	0.0038	0.0046	0.9498	0.0025
59	4	4	0.0276	0.0010	0.0019	0.9682	0.0013
60	4	4	0.0086	0.0010	0.0010	0.9884	0.0010
61	4	4	0.0174	0.0010	0.0018	0.9785	0.0012
62	4	4	0.0186	0.0010	0.0010	0.9784	0.0010
63	4	4	0.0264	0.0010	0.0015	0.9690	0.0021
64	4	4	0.0245	0.0012	0.0015	0.9703	0.0025
65	4	4	0.0192	0.0010	0.0010	0.9778	0.0010
66	4	4	0.0232	0.0017	0.0029	0.9706	0.0016
67	4	4	0.0296	0.0010	0.0028	0.9656	0.0010
68	4	4	0.0299	0.0010	0.0024	0.9657	0.0010
69	4	4	0.0427	0.0010	0.0034	0.9516	0.0013
70	4	4	0.0367	0.0010	0.0028	0.9585	0.0010
71	4	4	0.0699	0.0014	0.0038	0.9232	0.0017
72	4	4	0.0737	0.0010	0.0027	0.9215	0.0011
73	4	4	0.0622	0.0010	0.0012	0.9346	0.0010
74	4	4	0.0493	0.0010	0.0010	0.9477	0.0010
75	4	4	0.0600	0.0010	0.0010	0.9369	0.0011
76	4	4	0.1062	0.0013	0.0016	0.8897	0.0012

77		4	4	0.1112	0.0010	0.0013	0.8854	0.0010
78		4	4	0.1069	0.0010	0.0010	0.8898	0.0013
79		4	4	0.1078	0.0010	0.0010	0.8887	0.0014
80		4	4	0.1233	0.0010	0.0010	0.8737	0.0010
81		4	4	0.1323	0.0012	0.0012	0.8637	0.0016
82		4	4	0.1498	0.0010	0.0010	0.8472	0.0010
83		4	4	0.1013	0.0010	0.0010	0.8957	0.0010
84		4	4	0.1300	0.0012	0.0015	0.8663	0.0011
85		4	4	0.0400	0.0012	0.0012	0.9566	0.0010
86		4	4	0.0624	0.0056	0.0024	0.9286	0.0010
87		4	4	0.0483	0.0036	0.0017	0.9454	0.0010
88		4	4	0.0397	0.0010	0.0010	0.9573	0.0010
89		4	4	0.0660	0.0015	0.0011	0.9303	0.0010
90		4	4	0.0695	0.0010	0.0010	0.9275	0.0010
91		4	4	0.0841	0.0012	0.0010	0.9124	0.0013
92		4	4	0.0978	0.0010	0.0010	0.8992	0.0010
93		4	4	0.0981	0.0010	0.0010	0.8989	0.0010
94	25	1	4	0.4188	0.0110	0.0030	0.5639	0.0033
95		1	1	0.7485	0.0049	0.0032	0.2402	0.0031
96		1	1	0.8259	0.0010	0.0013	0.1682	0.0037
97		1	1	0.8690	0.0010	0.0010	0.1261	0.0029
98		1	1	0.8827	0.0010	0.0010	0.1128	0.0024
99		1	1	0.8794	0.0010	0.0010	0.1166	0.0020
100		1	1	0.8443	0.0010	0.0010	0.1517	0.0020
101		1	1	0.8475	0.0010	0.0010	0.1490	0.0015
102		1	1	0.8934	0.0012	0.0011	0.1021	0.0021
103		1	1	0.9181	0.0020	0.0065	0.0719	0.0014
104		1	1	0.9838	0.0010	0.0048	0.0092	0.0012
105		1	1	0.9876	0.0010	0.0041	0.0063	0.0011
106		1	1	0.9891	0.0010	0.0027	0.0062	0.0011
107		1	1	0.9887	0.0010	0.0023	0.0070	0.0010
108		1	1	0.9894	0.0010	0.0017	0.0069	0.0010
109		1	1	0.9898	0.0010	0.0014	0.0068	0.0010
110		1	1	0.9876	0.0010	0.0016	0.0081	0.0017
111		1	1	0.9904	0.0010	0.0013	0.0059	0.0013
112		1	1	0.9906	0.0010	0.0014	0.0053	0.0017
113		1	1	0.9816	0.0018	0.0027	0.0124	0.0015
114		1	1	0.9861	0.0011	0.0022	0.0093	0.0013
115		1	1	0.9889	0.0010	0.0015	0.0076	0.0011
116		1	1	0.9866	0.0010	0.0011	0.0103	0.0010
117		1	1	0.9862	0.0010	0.0010	0.0107	0.0010

118	1	1	0.9722	0.0010	0.0010	0.0248	0.0010
119	1	1	0.9799	0.0010	0.0010	0.0171	0.0010
120	1	1	0.9870	0.0010	0.0010	0.0100	0.0010
121	1	1	0.9858	0.0011	0.0011	0.0110	0.0010
122	1	1	0.9879	0.0010	0.0012	0.0089	0.0010
123	1	1	0.9937	0.0010	0.0010	0.0033	0.0010
124	1	1	0.9932	0.0013	0.0012	0.0027	0.0017
125	1	1	0.9939	0.0010	0.0012	0.0029	0.0010
126	1	1	0.9930	0.0010	0.0015	0.0035	0.0010
127	1	1	0.9919	0.0016	0.0011	0.0044	0.0010
128	1	1	0.9813	0.0021	0.0020	0.0136	0.0010
129	1	1	0.9820	0.0019	0.0016	0.0135	0.0010
130	1	1	0.9835	0.0010	0.0014	0.0131	0.0010
131	1	1	0.9826	0.0010	0.0013	0.0141	0.0010
132	1	1	0.9885	0.0010	0.0010	0.0081	0.0013
133	1	1	0.9893	0.0010	0.0010	0.0077	0.0010
134	1	1	0.9877	0.0010	0.0010	0.0093	0.0010
135	1	1	0.9882	0.0010	0.0010	0.0088	0.0010
136	1	1	0.9842	0.0010	0.0011	0.0126	0.0011
137	1	1	0.9841	0.0010	0.0010	0.0129	0.0010
138	1	1	0.9848	0.0010	0.0010	0.0122	0.0010
139	1	1	0.9793	0.0013	0.0010	0.0170	0.0014
140	1	1	0.9884	0.0010	0.0013	0.0081	0.0012
141	1	1	0.9444	0.0062	0.0017	0.0463	0.0015
142	1	1	0.9758	0.0010	0.0010	0.0212	0.0010
143	1	1	0.9823	0.0010	0.0010	0.0147	0.0010
144	1	1	0.9851	0.0010	0.0010	0.0119	0.0010
145	1	1	0.9870	0.0010	0.0010	0.0100	0.0010
146	1	1	0.9878	0.0010	0.0010	0.0092	0.0010
147	1	1	0.9904	0.0010	0.0010	0.0064	0.0012
148	1	1	0.9922	0.0010	0.0010	0.0048	0.0010
149	1	1	0.9930	0.0010	0.0010	0.0040	0.0010
150	1	1	0.9796	0.0113	0.0019	0.0052	0.0020
151	1	1	0.9845	0.0087	0.0010	0.0048	0.0010
152	1	1	0.9382	0.0340	0.0011	0.0257	0.0010
153	1	1	0.9632	0.0179	0.0011	0.0169	0.0010
154	1	1	0.9691	0.0153	0.0015	0.0131	0.0010
155	1	1	0.9771	0.0111	0.0010	0.0098	0.0010
156	1	1	0.9828	0.0072	0.0010	0.0080	0.0010
157	1	1	0.9815	0.0095	0.0010	0.0070	0.0010
158	1	1	0.9845	0.0071	0.0010	0.0064	0.0010

159	1	1	0.9851	0.0065	0.0010	0.0064	0.0010
160	1	1	0.9852	0.0046	0.0010	0.0081	0.0010
161	1	1	0.9857	0.0041	0.0010	0.0082	0.0010
162	1	1	0.8651	0.0013	0.0020	0.1296	0.0020
163	1	1	0.9772	0.0010	0.0024	0.0177	0.0017
164	1	1	0.9897	0.0010	0.0013	0.0064	0.0016
165	1	1	0.9932	0.0010	0.0010	0.0038	0.0011
166	1	1	0.9930	0.0010	0.0010	0.0040	0.0010
167	1	1	0.9939	0.0010	0.0010	0.0031	0.0010
168	1	1	0.9915	0.0010	0.0015	0.0049	0.0010
169	1	1	0.9914	0.0010	0.0016	0.0050	0.0010
170	1	1	0.9930	0.0010	0.0013	0.0037	0.0010
171	1	1	0.9823	0.0049	0.0095	0.0024	0.0010
172	1	1	0.9942	0.0010	0.0028	0.0010	0.0010
173	1	1	0.9954	0.0010	0.0017	0.0010	0.0010
174	1	1	0.9954	0.0011	0.0012	0.0013	0.0011
175	1	1	0.9960	0.0010	0.0010	0.0010	0.0010
176	1	1	0.9957	0.0010	0.0010	0.0012	0.0011
177	1	1	0.9953	0.0013	0.0010	0.0014	0.0010
178	1	1	0.9943	0.0015	0.0012	0.0020	0.0010
179	1	1	0.9947	0.0013	0.0012	0.0018	0.0010
180	1	1	0.9957	0.0010	0.0010	0.0013	0.0010
181	1	1	0.9953	0.0010	0.0011	0.0016	0.0010
182	1	1	0.9954	0.0010	0.0010	0.0016	0.0010
183	1	1	0.9959	0.0010	0.0010	0.0010	0.0011
184	1	1	0.9960	0.0010	0.0010	0.0010	0.0010
185	1	1	0.9958	0.0010	0.0012	0.0010	0.0010
186	1	1	0.9946	0.0016	0.0010	0.0018	0.0010
187	1	1	0.9954	0.0012	0.0010	0.0015	0.0010
188	1	1	0.9956	0.0012	0.0010	0.0012	0.0010
189	1	1	0.9920	0.0027	0.0012	0.0031	0.0010
190	1	1	0.9942	0.0014	0.0010	0.0025	0.0010
191	1	1	0.9944	0.0026	0.0010	0.0010	0.0010
192	1	1	0.9909	0.0036	0.0021	0.0015	0.0019
193	1	1	0.9892	0.0049	0.0030	0.0017	0.0012
194	1	1	0.9894	0.0045	0.0031	0.0019	0.0010
195	1	1	0.9922	0.0031	0.0023	0.0013	0.0010
196	1	1	0.9839	0.0060	0.0046	0.0045	0.0010
197	1	1	0.9882	0.0051	0.0027	0.0030	0.0010
198	1	1	0.9910	0.0038	0.0019	0.0024	0.0010
199	1	1	0.9914	0.0033	0.0018	0.0025	0.0010

200	1	1	0.9836	0.0077	0.0010	0.0052	0.0024
201	1	1	0.9882	0.0050	0.0010	0.0046	0.0012
202	1	1	0.9909	0.0037	0.0010	0.0034	0.0010
203	1	1	0.9920	0.0030	0.0010	0.0030	0.0010
204	1	1	0.9922	0.0026	0.0010	0.0032	0.0010
205	1	1	0.9931	0.0016	0.0010	0.0033	0.0010
206	1	1	0.9929	0.0012	0.0010	0.0039	0.0010
207	1	1	0.9932	0.0012	0.0010	0.0035	0.0011
208	1	1	0.9941	0.0010	0.0010	0.0029	0.0010
209	1	1	0.9941	0.0016	0.0011	0.0021	0.0011
210	1	1	0.9945	0.0015	0.0011	0.0019	0.0010
211	1	1	0.9936	0.0013	0.0011	0.0030	0.0010
212	1	1	0.9918	0.0015	0.0012	0.0044	0.0010
213	1	1	0.9918	0.0015	0.0012	0.0044	0.0011
214	1	1	0.9929	0.0010	0.0010	0.0041	0.0010
215	1	1	0.9909	0.0019	0.0016	0.0045	0.0011
216	1	1	0.9931	0.0014	0.0014	0.0031	0.0010
217	1	1	0.9934	0.0012	0.0011	0.0032	0.0011
218	1	1	0.9889	0.0051	0.0021	0.0022	0.0017
219	1	1	0.9923	0.0037	0.0010	0.0020	0.0010
220	1	1	0.9921	0.0033	0.0011	0.0025	0.0010
221	1	1	0.9906	0.0041	0.0010	0.0033	0.0010
222	1	1	0.9919	0.0034	0.0010	0.0027	0.0010
223	1	1	0.9897	0.0050	0.0015	0.0028	0.0010
224	1	1	0.9913	0.0039	0.0013	0.0025	0.0010
225	1	1	0.9908	0.0040	0.0013	0.0029	0.0010
226	1	1	0.9900	0.0067	0.0010	0.0013	0.0010
227	1	1	0.9904	0.0062	0.0010	0.0013	0.0011
228	1	1	0.9946	0.0021	0.0010	0.0013	0.0010
229	1	1	0.9950	0.0017	0.0010	0.0013	0.0010
230	1	1	0.8701	0.1029	0.0051	0.0209	0.0010
231	1	1	0.8832	0.0910	0.0058	0.0190	0.0010
232	1	1	0.9196	0.0616	0.0048	0.0130	0.0010
233	1	1	0.9117	0.0643	0.0025	0.0201	0.0014
234	1	1	0.9326	0.0442	0.0024	0.0196	0.0013
235	1	1	0.9389	0.0386	0.0019	0.0196	0.0010
236	1	1	0.9535	0.0295	0.0016	0.0145	0.0010
237	1	1	0.9500	0.0319	0.0018	0.0152	0.0010
238	1	1	0.9589	0.0246	0.0016	0.0139	0.0010
239	1	1	0.7330	0.1092	0.0045	0.1518	0.0015
240	1	1	0.8111	0.0434	0.0036	0.1405	0.0015

E.2 KREST Results from Trajectory Two Residuals.

KREST: Kalman filter Expert SysTem.
NFRMS: 240
ITraj: 2

#	Rule	KR	MAP	P1	P2	P3	P4	P5
1		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
2		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
3		1	1	0.9605	0.0092	0.0100	0.0103	0.0099
4		1	1	0.9644	0.0014	0.0091	0.0178	0.0073
5		1	1	0.9046	0.0040	0.0140	0.0676	0.0098
6		1	1	0.8829	0.0051	0.0122	0.0900	0.0099
7		1	1	0.8849	0.0014	0.0082	0.0967	0.0087
8		1	1	0.8909	0.0013	0.0079	0.0918	0.0081
9		1	1	0.9001	0.0010	0.0077	0.0841	0.0071
10		1	1	0.9025	0.0013	0.0068	0.0812	0.0082
11		1	1	0.8835	0.0010	0.0070	0.1001	0.0084
12		1	1	0.8835	0.0010	0.0059	0.1036	0.0060
13		1	1	0.8625	0.0010	0.0053	0.1255	0.0057
14		1	1	0.8797	0.0010	0.0040	0.1121	0.0032
15		1	1	0.8957	0.0010	0.0039	0.0964	0.0030
16		1	1	0.8840	0.0010	0.0038	0.1083	0.0029
17		1	1	0.8948	0.0010	0.0039	0.0979	0.0024
18		1	1	0.9270	0.0010	0.0039	0.0672	0.0010
19		1	1	0.8661	0.0010	0.0025	0.1294	0.0010
20		1	1	0.9143	0.0010	0.0010	0.0827	0.0010
21		1	1	0.9020	0.0010	0.0010	0.0949	0.0011
22		1	1	0.9586	0.0010	0.0012	0.0383	0.0010
23		1	1	0.9668	0.0010	0.0010	0.0302	0.0010
24		1	1	0.9636	0.0010	0.0010	0.0334	0.0010
25		1	1	0.9634	0.0010	0.0010	0.0336	0.0010
26		1	1	0.7833	0.0010	0.0010	0.2137	0.0010
27		1	1	0.7072	0.0010	0.0010	0.2898	0.0010
28		1	1	0.8328	0.0017	0.0010	0.1635	0.0010
29		1	1	0.8499	0.0010	0.0010	0.1471	0.0010
30		1	1	0.8297	0.0010	0.0010	0.1673	0.0010
31		1	1	0.7769	0.0010	0.0010	0.2201	0.0010
32		1	1	0.7838	0.0010	0.0010	0.2132	0.0010
33		1	1	0.7676	0.0010	0.0010	0.2294	0.0010
34		1	1	0.7818	0.0010	0.0010	0.2152	0.0010
35	65	1	4	0.3677	0.0010	0.0010	0.6293	0.0010

36		4	4	0.2524	0.0010	0.0010	0.7446	0.0010
37		4	4	0.0835	0.0021	0.0010	0.9124	0.0010
38		4	4	0.0918	0.0018	0.0012	0.9043	0.0010
39		4	4	0.0903	0.0016	0.0012	0.9059	0.0010
40		4	4	0.1073	0.0010	0.0010	0.8896	0.0010
41		4	4	0.1377	0.0010	0.0010	0.8592	0.0011
42		4	4	0.0449	0.0010	0.0010	0.9521	0.0010
43		4	4	0.0366	0.0010	0.0010	0.9604	0.0010
44		4	4	0.0422	0.0011	0.0010	0.9544	0.0012
45		4	4	0.0261	0.0010	0.0013	0.9707	0.0010
46		4	4	0.0267	0.0010	0.0010	0.9703	0.0010
47		4	4	0.0325	0.0014	0.0014	0.9637	0.0010
48		4	4	0.0286	0.0010	0.0010	0.9684	0.0010
49		4	4	0.0345	0.0011	0.0015	0.9616	0.0014
50		4	4	0.0040	0.0010	0.0010	0.9930	0.0010
51		4	4	0.0037	0.0010	0.0011	0.9932	0.0010
52		4	4	0.0052	0.0010	0.0010	0.9918	0.0010
53		4	4	0.0114	0.0018	0.0010	0.9842	0.0016
54		4	4	0.0242	0.0026	0.0016	0.9687	0.0029
55		4	4	0.0343	0.0026	0.0021	0.9585	0.0025
56		4	4	0.0365	0.0040	0.0035	0.9515	0.0044
57		4	4	0.0411	0.0036	0.0035	0.9496	0.0022
58		4	4	0.0393	0.0038	0.0046	0.9498	0.0025
59		4	4	0.0276	0.0010	0.0019	0.9682	0.0013
60		4	4	0.0086	0.0010	0.0010	0.9884	0.0010
61		4	4	0.0174	0.0010	0.0018	0.9785	0.0012
62		4	4	0.0179	0.0010	0.0011	0.9790	0.0010
63		4	4	0.0369	0.0014	0.0029	0.9564	0.0024
64		4	4	0.0332	0.0252	0.0150	0.8690	0.0576
65	75	2	4	0.0194	0.1596	0.0631	0.4463	0.3115
66	75	2	5	0.0010	0.4115	0.0010	0.0010	0.5855
67		5	5	0.0010	0.3375	0.0035	0.0010	0.6571
68		5	5	0.0010	0.3250	0.0010	0.0010	0.6720
69		2	2	0.0010	0.5609	0.0010	0.0010	0.4361
70		2	2	0.0010	0.5193	0.0010	0.0010	0.4777
71		2	2	0.0010	0.5114	0.0010	0.0010	0.4856
72		5	5	0.0010	0.2619	0.0010	0.0010	0.7351
73		2	2	0.0010	0.5050	0.0010	0.0010	0.4920
74		5	5	0.0010	0.2334	0.0010	0.0010	0.7636
75		5	5	0.0010	0.1971	0.0010	0.0010	0.7999
76		2	2	0.0010	0.9960	0.0010	0.0010	0.0010

77		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
78		2	2	0.0014	0.9941	0.0014	0.0015	0.0016
79		2	2	0.0021	0.9899	0.0028	0.0024	0.0028
80		2	2	0.0057	0.9721	0.0059	0.0084	0.0079
81		2	2	0.0093	0.9582	0.0082	0.0129	0.0114
82		2	2	0.0245	0.8937	0.0176	0.0352	0.0292
83		2	2	0.0190	0.9005	0.0138	0.0409	0.0258
84		2	2	0.1003	0.5316	0.0794	0.2063	0.0824
85	75	2	4	0.1452	0.3067	0.1334	0.4017	0.0130
86	70	1	4	0.1871	0.1637	0.1797	0.4611	0.0085
87	70	1	4	0.2382	0.0168	0.1750	0.5682	0.0018
88		4	4	0.2123	0.0398	0.0877	0.6556	0.0045
89	25	1	4	0.3316	0.0348	0.1385	0.4915	0.0035
90	25	1	4	0.3501	0.0445	0.1168	0.4838	0.0047
91	25	1	4	0.3705	0.0556	0.0992	0.4680	0.0068
92	25	1	4	0.3949	0.0492	0.1016	0.4493	0.0050
93	25	1	4	0.3991	0.0449	0.0975	0.4531	0.0054
94	25	1	4	0.4310	0.0052	0.0689	0.4939	0.0010
95		1	1	0.6342	0.0010	0.0811	0.2827	0.0010
96		1	1	0.7714	0.0010	0.0491	0.1771	0.0014
97		1	1	0.8393	0.0010	0.0397	0.1182	0.0018
98		1	1	0.8556	0.0010	0.0335	0.1082	0.0017
99		1	1	0.9089	0.0010	0.0329	0.0562	0.0010
100		1	1	0.8991	0.0011	0.0289	0.0696	0.0013
101		1	1	0.9223	0.0010	0.0203	0.0554	0.0010
102		1	1	0.9280	0.0010	0.0176	0.0524	0.0010
103		1	1	0.9232	0.0010	0.0725	0.0023	0.0010
104		1	1	0.9431	0.0010	0.0539	0.0010	0.0010
105		1	1	0.9479	0.0010	0.0491	0.0010	0.0010
106		1	1	0.9612	0.0010	0.0358	0.0010	0.0010
107		1	1	0.9527	0.0019	0.0429	0.0010	0.0014
108		1	1	0.9514	0.0017	0.0443	0.0010	0.0015
109		1	1	0.9554	0.0017	0.0402	0.0010	0.0017
110		1	1	0.9417	0.0077	0.0412	0.0010	0.0083
111		1	1	0.9378	0.0075	0.0444	0.0010	0.0093
112		1	1	0.9311	0.0092	0.0513	0.0012	0.0072
113		1	1	0.9150	0.0232	0.0522	0.0013	0.0084
114		1	1	0.8969	0.0326	0.0561	0.0012	0.0133
115		1	1	0.8866	0.0396	0.0627	0.0010	0.0101
116		1	1	0.7810	0.1015	0.0917	0.0010	0.0248
117		1	1	0.7207	0.1235	0.1255	0.0012	0.0291

118		2	2	0.2131	0.5801	0.1786	0.0037	0.0245
119		2	2	0.2427	0.5218	0.2107	0.0036	0.0212
120	55	3	2	0.1646	0.4378	0.3703	0.0033	0.0240
121	55	3	2	0.0569	0.5240	0.4081	0.0023	0.0087
122	55	3	2	0.0454	0.4991	0.4461	0.0023	0.0072
123		3	3	0.1934	0.0659	0.7119	0.0076	0.0212
124		3	3	0.1903	0.0464	0.7371	0.0068	0.0194
125		3	3	0.0981	0.0673	0.8151	0.0136	0.0060
126		3	3	0.0517	0.0628	0.8666	0.0147	0.0042
127		3	3	0.0858	0.1057	0.7833	0.0180	0.0072
128		3	3	0.0178	0.2702	0.6952	0.0142	0.0026
129		3	3	0.0062	0.3994	0.5822	0.0083	0.0038
130		3	3	0.0057	0.3650	0.6203	0.0069	0.0022
131		3	3	0.0026	0.4695	0.5203	0.0058	0.0017
132	30	3	2	0.0010	0.5752	0.4189	0.0013	0.0036
133		3	3	0.0022	0.2635	0.7300	0.0027	0.0016
134		3	3	0.0010	0.2494	0.7476	0.0010	0.0010
135		3	3	0.0010	0.2126	0.7844	0.0010	0.0010
136		3	3	0.0010	0.2415	0.7551	0.0010	0.0014
137		3	3	0.0010	0.1898	0.8068	0.0010	0.0014
138		3	3	0.0010	0.1733	0.8237	0.0010	0.0010
139		3	3	0.0010	0.3832	0.6134	0.0010	0.0014
140		3	3	0.0010	0.4667	0.5303	0.0010	0.0010
141	30	3	2	0.0010	0.6509	0.3455	0.0015	0.0010
142	30	3	2	0.0013	0.5463	0.4499	0.0012	0.0013
143	30	3	2	0.0018	0.5188	0.4767	0.0012	0.0015
144		3	3	0.0010	0.4584	0.5381	0.0010	0.0015
145		3	3	0.0010	0.4631	0.5335	0.0010	0.0013
146		3	3	0.0010	0.4267	0.5703	0.0010	0.0010
147		3	3	0.0010	0.4049	0.5920	0.0011	0.0010
148	30	3	2	0.0010	0.5294	0.4676	0.0011	0.0010
149		3	3	0.0011	0.4604	0.5363	0.0010	0.0011
150		3	3	0.0014	0.0606	0.9351	0.0019	0.0010
151		3	3	0.0020	0.0268	0.9662	0.0040	0.0010
152		3	3	0.0018	0.0334	0.9577	0.0062	0.0010
153		3	3	0.0039	0.0834	0.8813	0.0298	0.0016
154		3	3	0.0046	0.0436	0.9258	0.0249	0.0010
155		3	3	0.0055	0.1924	0.7499	0.0511	0.0012
156		3	3	0.0057	0.1529	0.8033	0.0365	0.0016
157		3	3	0.0036	0.2770	0.6914	0.0255	0.0024
158		3	3	0.0029	0.2436	0.7266	0.0241	0.0028

159	3	3	0.0017	0.3131	0.6603	0.0208	0.0041
160	3	3	0.0028	0.2789	0.6825	0.0348	0.0010
161	3	3	0.0029	0.2175	0.7348	0.0438	0.0010
162	3	3	0.0010	0.0384	0.8851	0.0745	0.0010
163	3	3	0.0010	0.0053	0.9696	0.0231	0.0010
164	3	3	0.0013	0.0058	0.9801	0.0100	0.0028
165	3	3	0.0017	0.0035	0.9858	0.0037	0.0053
166	3	3	0.0010	0.0032	0.9902	0.0043	0.0013
167	3	3	0.0010	0.0018	0.9918	0.0043	0.0010
168	3	3	0.0010	0.0023	0.9900	0.0057	0.0010
169	3	3	0.0010	0.0016	0.9905	0.0059	0.0010
170	3	3	0.0010	0.0014	0.9916	0.0050	0.0010
171	3	3	0.0010	0.0039	0.9664	0.0277	0.0010
172	3	3	0.0023	0.0052	0.9352	0.0554	0.0019
173	3	3	0.0029	0.0047	0.9451	0.0446	0.0027
174	3	3	0.0047	0.0083	0.9393	0.0405	0.0072
175	3	3	0.0036	0.0063	0.9557	0.0273	0.0072
176	3	3	0.0050	0.0071	0.9484	0.0293	0.0102
177	3	3	0.0044	0.0091	0.9503	0.0204	0.0158
178	3	3	0.0041	0.0087	0.9540	0.0172	0.0160
179	3	3	0.0047	0.0100	0.9511	0.0136	0.0205
180	3	3	0.0054	0.0022	0.9741	0.0128	0.0055
181	3	3	0.0048	0.0014	0.9789	0.0102	0.0047
182	3	3	0.0066	0.002[illegible]	0.9722	0.0149	0.0043
183	3	3	0.0058	0.0017	0.9770	0.0131	0.0024
184	3	3	0.0050	0.0019	0.9771	0.0142	0.0018
185	3	3	0.0040	0.0018	0.9748	0.0185	0.0010
186	3	3	0.0028	0.0031	0.9066	0.0863	0.0013
187	3	3	0.0016	0.0027	0.9199	0.0747	0.0010
188	3	3	0.0010	0.0048	0.9157	0.0775	0.0010
189	3	3	0.0010	0.0070	0.8824	0.1086	0.0010
190	3	3	0.0010	0.0060	0.8900	0.1020	0.0010
191	3	3	0.0021	0.0014	0.8796	0.1158	0.0010
192	3	3	0.0014	0.0018	0.8962	0.0993	0.0012
193	3	3	0.0010	0.0019	0.8669	0.1293	0.0010
194	3	3	0.0010	0.0021	0.8317	0.1642	0.0010
195	3	3	0.0015	0.0022	0.7720	0.2230	0.0013
196	3	3	0.0010	0.0107	0.6231	0.3642	0.0010
197	3	3	0.0010	0.0063	0.5988	0.3926	0.0012
198	3	3	0.0013	0.0056	0.5393	0.4524	0.0014
199	3	3	0.0010	0.0061	0.5050	0.4869	0.0010

200	4	4	0.0012	0.0155	0.4300	0.5500	0.0034
201	4	4	0.0015	0.0110	0.4515	0.5328	0.0032
202	4	4	0.0017	0.0137	0.4806	0.4996	0.0044
203	3	3	0.0015	0.0146	0.5544	0.4245	0.0049
204	3	3	0.0018	0.0137	0.5498	0.4296	0.0052
205	3	3	0.0021	0.0126	0.5444	0.4377	0.0033
206	3	3	0.0012	0.0257	0.4943	0.4746	0.0042
207	3	3	0.0010	0.0352	0.5340	0.4232	0.0067
208	3	3	0.0010	0.0375	0.5512	0.4042	0.0061
209	3	3	0.0010	0.1098	0.6205	0.2621	0.0066
210	3	3	0.0010	0.0870	0.6674	0.2396	0.0050
211	3	3	0.0010	0.0541	0.6694	0.2735	0.0020
212	3	3	0.0010	0.0688	0.5826	0.3461	0.0014
213	3	3	0.0010	0.0880	0.6131	0.2968	0.0011
214	3	3	0.0010	0.0702	0.6296	0.2982	0.0010
215	3	3	0.0010	0.0791	0.5750	0.3439	0.0010
216	3	3	0.0011	0.0643	0.6220	0.3117	0.0010
217	3	3	0.0015	0.0613	0.6449	0.2911	0.0012
218	3	3	0.0013	0.0161	0.6665	0.3152	0.0010
219	4	4	0.0016	0.0101	0.3571	0.6303	0.0010
220	4	4	0.0010	0.0078	0.2996	0.6907	0.0010
221	4	4	0.0010	0.0101	0.2346	0.7533	0.0010
222	4	4	0.0010	0.0085	0.2304	0.7592	0.0010
223	4	4	0.0010	0.0069	0.2628	0.7283	0.0010
224	4	4	0.0010	0.0086	0.2292	0.7602	0.0010
225	4	4	0.0010	0.0118	0.2680	0.7181	0.0010
226	4	4	0.0011	0.0364	0.4454	0.5148	0.0023
227	4	4	0.0010	0.0482	0.4090	0.5394	0.0024
228	4	4	0.0012	0.0350	0.3057	0.6572	0.0010
229	4	4	0.0010	0.0253	0.2833	0.6895	0.0010
230	4	4	0.0010	0.0159	0.0326	0.9495	0.0010
231	4	4	0.0010	0.0154	0.0323	0.9504	0.0010
232	4	4	0.0010	0.0130	0.0326	0.9523	0.0010
233	4	4	0.0018	0.0170	0.0262	0.9534	0.0016
234	4	4	0.0012	0.0167	0.0273	0.9537	0.0010
235	4	4	0.0014	0.0120	0.0283	0.9573	0.0010
236	4	4	0.0014	0.0112	0.0306	0.9558	0.0010
237	4	4	0.0016	0.0102	0.0327	0.9544	0.0011
238	4	4	0.0022	0.0067	0.0340	0.9561	0.0010
239	4	4	0.0010	0.0010	0.1409	0.8560	0.0011
240	4	4	0.0027	0.0010	0.2164	0.7773	0.0025

E.3 KREST Results from Trajectory Three Residuals.

KREST: Kalman filter Expert SysTem.
NFRMS: 240
ITraj: 3

#	Rule	KR	MAP	P1	P2	P3	P4	P5
1		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
2		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
3		1	1	0.9605	0.0092	0.0100	0.0103	0.0099
4		1	1	0.9644	0.0014	0.0091	0.0178	0.0073
5		1	1	0.9046	0.0040	0.0140	0.0676	0.0098
6		1	1	0.8829	0.0051	0.0122	0.0900	0.0099
7		1	1	0.8849	0.0014	0.0082	0.0967	0.0087
8		1	1	0.8909	0.0013	0.0079	0.0918	0.0081
9		1	1	0.9001	0.0010	0.0077	0.0841	0.0071
10		1	1	0.9025	0.0013	0.0068	0.0812	0.0082
11		1	1	0.8835	0.0010	0.0070	0.1001	0.0084
12		1	1	0.8835	0.0010	0.0059	0.1036	0.0060
13		1	1	0.8625	0.0010	0.0053	0.1255	0.0057
14		1	1	0.8797	0.0010	0.0040	0.1121	0.0032
15		1	1	0.8957	0.0010	0.0039	0.0964	0.0030
16		1	1	0.8840	0.0010	0.0038	0.1083	0.0029
17		1	1	0.8948	0.0010	0.0039	0.0979	0.0024
18		1	1	0.9270	0.0010	0.0039	0.0672	0.0010
19		1	1	0.8661	0.0010	0.0025	0.1294	0.0010
20		1	1	0.9143	0.0010	0.0010	0.0827	0.0010
21		1	1	0.9020	0.0010	0.0010	0.0949	0.0011
22		1	1	0.9586	0.0010	0.0012	0.0383	0.0010
23		1	1	0.9668	0.0010	0.0010	0.0302	0.0010
24		1	1	0.9636	0.0010	0.0010	0.0334	0.0010
25		1	1	0.9634	0.0010	0.0010	0.0336	0.0010
26		1	1	0.7833	0.0010	0.0010	0.2137	0.0010
27		1	1	0.7072	0.0010	0.0010	0.2898	0.0010
28		1	1	0.8328	0.0017	0.0010	0.1635	0.0010
29		1	1	0.8499	0.0010	0.0010	0.1471	0.0010
30		1	1	0.8297	0.0010	0.0010	0.1673	0.0010
31		1	1	0.7769	0.0010	0.0010	0.2201	0.0010
32		1	1	0.7838	0.0010	0.0010	0.2132	0.0010
33		1	1	0.7676	0.0010	0.0010	0.2294	0.0010
34		1	1	0.7818	0.0010	0.0010	0.2152	0.0010
35	65	1	4	0.3677	0.0010	0.0010	0.6293	0.0010

36		4	4	0.2524	0.0010	0.0010	0.7446	0.0010
37		4	4	0.0835	0.0021	0.0010	0.9124	0.0010
38		4	4	0.0918	0.0018	0.0012	0.9043	0.0010
39		4	4	0.0903	0.0016	0.0012	0.9059	0.0010
40		4	4	0.1073	0.0010	0.0010	0.8896	0.0010
41		4	4	0.1377	0.0010	0.0010	0.8592	0.0011
42		4	4	0.0449	0.0010	0.0010	0.9521	0.0010
43		4	4	0.0366	0.0010	0.0010	0.9604	0.0010
44		4	4	0.0422	0.0011	0.0010	0.9544	0.0012
45		4	4	0.0261	0.0010	0.0013	0.9707	0.0010
46		4	4	0.0267	0.0010	0.0010	0.9703	0.0010
47		4	4	0.0325	0.0014	0.0014	0.9637	0.0010
48		4	4	0.0286	0.0010	0.0010	0.9684	0.0010
49		4	4	0.0345	0.0011	0.0015	0.9616	0.0014
50		4	4	0.0040	0.0010	0.0010	0.9930	0.0010
51		4	4	0.0037	0.0010	0.0011	0.9932	0.0010
52		4	4	0.0052	0.0010	0.0010	0.9918	0.0010
53		4	4	0.0114	0.0018	0.0010	0.9842	0.0016
54		4	4	0.0242	0.0026	0.0016	0.9687	0.0029
55		4	4	0.0343	0.0026	0.0021	0.9585	0.0025
56		4	4	0.0365	0.0040	0.0035	0.9515	0.0044
57		4	4	0.0411	0.0036	0.0035	0.9496	0.0022
58		4	4	0.0393	0.0038	0.0046	0.9498	0.0025
59		4	4	0.0276	0.0010	0.0019	0.9682	0.0013
60		4	4	0.0086	0.0010	0.0010	0.9884	0.0010
61		4	4	0.0174	0.0010	0.0018	0.9785	0.0012
62		4	4	0.0179	0.0010	0.0011	0.9790	0.0010
63		4	4	0.0369	0.0014	0.0029	0.9564	0.0024
64		4	4	0.0332	0.0252	0.0150	0.8690	0.0576
65	75	2	4	0.0194	0.1596	0.0631	0.4463	0.3115
66	75	2	5	0.0010	0.4115	0.0010	0.0010	0.5855
67		5	5	0.0010	0.3375	0.0035	0.0010	0.6571
68		5	5	0.0010	0.3250	0.0010	0.0010	0.6720
69		2	2	0.0010	0.5609	0.0010	0.0010	0.4361
70		2	2	0.0010	0.5193	0.0010	0.0010	0.4777
71		2	2	0.0010	0.5114	0.0010	0.0010	0.4856
72		5	5	0.0010	0.2619	0.0010	0.0010	0.7351
73		2	2	0.0010	0.5050	0.0010	0.0010	0.4920
74		5	5	0.0010	0.2334	0.0010	0.0010	0.7636
75		5	5	0.0010	0.1971	0.0010	0.0010	0.7999
76		2	2	0.0010	0.9960	0.0010	0.0010	0.0010

77		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
78		2	2	0.0014	0.9941	0.0014	0.0015	0.0016
79		2	2	0.0021	0.9899	0.0028	0.0024	0.0028
80		2	2	0.0057	0.9721	0.0059	0.0084	0.0079
81		2	2	0.0093	0.9582	0.0082	0.0129	0.0114
82		2	2	0.0245	0.8937	0.0176	0.0352	0.0292
83		2	2	0.0190	0.9005	0.0138	0.0409	0.0258
84		2	2	0.1003	0.5316	0.0794	0.2063	0.0824
85	75	2	4	0.1452	0.3067	0.1334	0.4017	0.0130
86	70	1	4	0.1871	0.1637	0.1797	0.4611	0.0085
87	70	1	4	0.2382	0.0168	0.1750	0.5682	0.0018
88		4	4	0.2123	0.0398	0.0877	0.6556	0.0045
89	25	1	4	0.3316	0.0348	0.1385	0.4915	0.0035
90	25	1	4	0.3501	0.0445	0.1168	0.4838	0.0047
91	25	1	4	0.3705	0.0556	0.0992	0.4680	0.0068
92	25	1	4	0.3949	0.0492	0.1016	0.4493	0.0050
93	25	1	4	0.3991	0.0449	0.0975	0.4531	0.0054
94	25	1	4	0.4310	0.0052	0.0689	0.4939	0.0010
95		1	1	0.6342	0.0010	0.0811	0.2827	0.0010
96		1	1	0.7714	0.0010	0.0491	0.1771	0.0014
97		1	1	0.8393	0.0010	0.0397	0.1182	0.0018
98		1	1	0.8556	0.0010	0.0335	0.1082	0.0017
99		1	1	0.9089	0.0010	0.0329	0.0562	0.0010
100		1	1	0.8991	0.0011	0.0289	0.0696	0.0013
101		1	1	0.9223	0.0010	0.0203	0.0554	0.0010
102		1	1	0.9280	0.0010	0.0176	0.0524	0.0010
103		1	1	0.9232	0.0010	0.0725	0.0023	0.0010
104		1	1	0.9431	0.0010	0.0539	0.0010	0.0010
105		1	1	0.9479	0.0010	0.0491	0.0010	0.0010
106		1	1	0.9612	0.0010	0.0358	0.0010	0.0010
107		1	1	0.9564	0.0011	0.0403	0.0010	0.0011
108		1	1	0.9639	0.0010	0.0331	0.0010	0.0010
109		1	1	0.9543	0.0010	0.0427	0.0010	0.0010
110		1	1	0.9684	0.0010	0.0286	0.0010	0.0010
111		1	1	0.7493	0.0068	0.2285	0.0012	0.0141
112	45	2	5	0.0106	0.1004	0.4088	0.0010	0.4792
113		2	2	0.0010	0.8043	0.1404	0.0010	0.0533
114		2	2	0.0010	0.8528	0.0618	0.0010	0.0835
115		2	2	0.0010	0.8743	0.0069	0.0010	0.1168
116		2	2	0.0010	0.7134	0.0096	0.0010	0.2750
117		2	2	0.0010	0.5463	0.0054	0.0010	0.4462

118	5	5	0.0010	0.3182	0.0019	0.0010	0.6779
119	5	5	0.0010	0.1983	0.0010	0.0010	0.7987
120	5	5	0.0010	0.0350	0.0027	0.0010	0.9604
121	5	5	0.0010	0.0180	0.0022	0.0010	0.9778
122	5	5	0.0010	0.0151	0.0010	0.0010	0.9819
123	5	5	0.0010	0.0176	0.0010	0.0010	0.9794
124	5	5	0.0010	0.0105	0.0010	0.0010	0.9865
125	5	5	0.0010	0.0088	0.0017	0.0010	0.9875
126	5	5	0.0010	0.0077	0.0016	0.0010	0.9887
127	5	5	0.0010	0.0372	0.0032	0.0010	0.9576
128	5	5	0.0010	0.0263	0.0020	0.0010	0.9697
129	5	5	0.0010	0.0275	0.0017	0.0010	0.9688
130	5	5	0.0010	0.0093	0.0029	0.0010	0.9858
131	5	5	0.0010	0.0033	0.0033	0.0010	0.9914
132	5	5	0.0011	0.0052	0.0022	0.0010	0.9906
133	5	5	0.0010	0.0010	0.0028	0.0010	0.9942
134	5	5	0.0010	0.0010	0.0028	0.0010	0.9942
135	5	5	0.0010	0.0010	0.0037	0.0010	0.9933
136	5	5	0.0011	0.0010	0.0037	0.0012	0.9929
137	5	5	0.0010	0.0011	0.0035	0.0010	0.9934
138	5	5	0.0012	0.0010	0.0030	0.0010	0.9938
139	5	5	0.0010	0.0010	0.0013	0.0012	0.9954
140	5	5	0.0013	0.0010	0.0017	0.0011	0.9949
141	5	5	0.0010	0.0027	0.0016	0.0026	0.9921
142	5	5	0.0019	0.0010	0.0017	0.0027	0.9926
143	5	5	0.0024	0.0010	0.0012	0.0020	0.9934
144	5	5	0.0027	0.0010	0.0012	0.0015	0.9935
145	5	5	0.0029	0.0010	0.0012	0.0016	0.9933
146	5	5	0.0040	0.0010	0.0013	0.0018	0.9918
147	5	5	0.0047	0.0010	0.0011	0.0020	0.9912
148	5	5	0.0034	0.0010	0.0010	0.0022	0.9924
149	5	5	0.0039	0.0010	0.0010	0.0017	0.9924
150	5	5	0.0264	0.0010	0.0037	0.0107	0.9582
151	5	5	0.1362	0.0010	0.0169	0.0544	0.7915
152	5	5	0.0378	0.0340	0.0109	0.3531	0.5642
153	5	5	0.0478	0.0250	0.0115	0.3382	0.5775
154	5	5	0.0513	0.0080	0.0105	0.3686	0.5617
155	5	5	0.0606	0.0061	0.0094	0.3918	0.5322
156	5	5	0.0583	0.0050	0.0100	0.2540	0.6727
157	5	5	0.0345	0.0053	0.0075	0.1655	0.7873
158	5	5	0.0386	0.0047	0.0076	0.1500	0.7991

159		5	5	0.0382	0.0042	0.0069	0.1267	0.8239
160	70	1	5	0.1276	0.0010	0.0109	0.3461	0.5144
161	70	1	5	0.1412	0.0010	0.0080	0.3438	0.5059
162		4	4	0.0213	0.0291	0.0068	0.8563	0.0864
163		4	4	0.0319	0.0131	0.0098	0.8337	0.1116
164	70	1	4	0.1246	0.0191	0.0183	0.4807	0.3574
165	70	1	5	0.1741	0.0039	0.0138	0.2818	0.5264
166	70	1	5	0.2125	0.0029	0.0152	0.2966	0.4729
167	70	1	5	0.1858	0.0026	0.0138	0.3078	0.4900
168	70	1	5	0.1948	0.0027	0.0294	0.3356	0.4374
169	70	1	5	0.1895	0.0024	0.0299	0.3722	0.4061
170	70	1	5	0.2170	0.0020	0.0297	0.3624	0.3890
171		3	3	0.1228	0.0052	0.5069	0.1733	0.1919
172	40	1	3	0.2866	0.0010	0.3552	0.0984	0.2589
173		1	1	0.4021	0.0010	0.2941	0.0662	0.2367
174		1	1	0.4882	0.0010	0.2034	0.0624	0.2450
175		1	1	0.5496	0.0010	0.1595	0.0544	0.2355
176		1	1	0.5604	0.0013	0.1484	0.0797	0.2102
177		1	1	0.6006	0.0017	0.1325	0.1000	0.1651
178		1	1	0.5433	0.0020	0.1619	0.1417	0.1510
179		1	1	0.5833	0.0017	0.1602	0.1409	0.1140
180		1	1	0.6505	0.0010	0.0945	0.1235	0.1306
181		1	1	0.6475	0.0010	0.1032	0.1537	0.0945
182		1	1	0.6912	0.0010	0.0456	0.1619	0.1003
183		1	1	0.7812	0.0010	0.0395	0.0849	0.0935
184		1	1	0.8141	0.0010	0.0338	0.0716	0.0795
185		1	1	0.7794	0.0010	0.0436	0.0641	0.1119
186		1	1	0.8753	0.0010	0.0196	0.0748	0.0293
187		1	1	0.8929	0.0010	0.0159	0.0652	0.0250
188		1	1	0.8944	0.0010	0.0165	0.0666	0.0215
189		1	1	0.8511	0.0010	0.0163	0.1164	0.0152
190		1	1	0.8908	0.0010	0.0138	0.0830	0.0114
191		1	1	0.9273	0.0010	0.0087	0.0376	0.0254
192		1	1	0.9160	0.0011	0.0130	0.0323	0.0377
193		1	1	0.9219	0.0012	0.0208	0.0401	0.0160
194		1	1	0.9155	0.0010	0.0240	0.0474	0.0121
195		1	1	0.9367	0.0010	0.0160	0.0354	0.0109
196		1	1	0.8809	0.0022	0.0129	0.0970	0.0069
197		1	1	0.9194	0.0012	0.0079	0.0667	0.0048
198		1	1	0.9463	0.0010	0.0062	0.0433	0.0032
199		1	1	0.9459	0.0010	0.0062	0.0446	0.0024

200	1	1	0.8839	0.0030	0.0043	0.1058	0.0031
201	1	1	0.8819	0.0032	0.0035	0.1094	0.0020
202	1	1	0.8930	0.0027	0.0031	0.0994	0.0018
203	1	1	0.9124	0.0020	0.0024	0.0816	0.0017
204	1	1	0.9022	0.0018	0.0020	0.0924	0.0016
205	1	1	0.8925	0.0017	0.0015	0.1031	0.0013
206	1	1	0.8761	0.0019	0.0010	0.1199	0.0011
207	1	1	0.8893	0.0012	0.0010	0.1073	0.0012
208	1	1	0.9022	0.0010	0.0010	0.0948	0.0010
209	1	1	0.9186	0.0012	0.0014	0.0776	0.0012
210	1	1	0.9311	0.0010	0.0014	0.0656	0.0010
211	1	1	0.9060	0.0010	0.0010	0.0910	0.0010
212	1	1	0.8448	0.0016	0.0015	0.1512	0.0010
213	1	1	0.8287	0.0011	0.0014	0.1677	0.0011
214	1	1	0.8466	0.0010	0.0010	0.1504	0.0010
215	1	1	0.8418	0.0010	0.0014	0.1547	0.0011
216	1	1	0.8839	0.0010	0.0012	0.1129	0.0010
217	1	1	0.8974	0.0010	0.0012	0.0995	0.0010
218	1	1	0.9119	0.0016	0.0021	0.0828	0.0016
219	1	1	0.9212	0.0010	0.0010	0.0757	0.0010
220	1	1	0.9087	0.0010	0.0010	0.0883	0.0010
221	1	1	0.8830	0.0013	0.0011	0.1136	0.0010
222	1	1	0.8960	0.0010	0.0010	0.1010	0.0010
223	1	1	0.9365	0.0016	0.0016	0.0588	0.0014
224	1	1	0.9414	0.0015	0.0014	0.0547	0.0010
225	1	1	0.9453	0.0010	0.0012	0.0515	0.0010
226	1	1	0.9727	0.0026	0.0015	0.0214	0.0018
227	1	1	0.9753	0.0021	0.0012	0.0198	0.0016
228	1	1	0.9780	0.0010	0.0010	0.0190	0.0010
229	1	1	0.9825	0.0010	0.0010	0.0145	0.0010
230	1	1	0.6593	0.0109	0.0035	0.3251	0.0013
231	1	1	0.6770	0.0061	0.0033	0.3126	0.0010
232	1	1	0.7081	0.0052	0.0032	0.2825	0.0010
233	1	1	0.6558	0.0068	0.0012	0.3352	0.0010
234	1	1	0.6798	0.0051	0.0011	0.3130	0.0010
235	1	1	0.6800	0.0050	0.0010	0.3129	0.0011
236	1	1	0.7486	0.0043	0.0010	0.2451	0.0010
237	1	1	0.7594	0.0039	0.0010	0.2347	0.0010
238	1	1	0.7691	0.0032	0.0010	0.2257	0.0010
239	4	4	0.2566	0.0037	0.0019	0.7368	0.0010
240	4	4	0.2418	0.0010	0.0012	0.7550	0.0010

E.4 KREST Results from Trajectory Four Residuals.

KREST: Kalman filter Expert SysTem.
NFRMS: 240
ITraj: 4

#	Rule	KR	MAP	P1	P2	P3	P4	P5
1		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
2		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
3		1	1	0.9605	0.0092	0.0100	0.0103	0.0099
4		1	1	0.9644	0.0014	0.0091	0.0178	0.0073
5		1	1	0.9046	0.0040	0.0140	0.0676	0.0098
6		1	1	0.8829	0.0051	0.0122	0.0900	0.0099
7		1	1	0.8849	0.0014	0.0082	0.0967	0.0087
8		1	1	0.8909	0.0013	0.0079	0.0918	0.0081
9		1	1	0.9001	0.0010	0.0077	0.0841	0.0071
10		1	1	0.9025	0.0013	0.0068	0.0812	0.0082
11		1	1	0.8835	0.0010	0.0070	0.1001	0.0084
12		1	1	0.8835	0.0010	0.0059	0.1036	0.0060
13		1	1	0.8625	0.0010	0.0053	0.1255	0.0057
14		1	1	0.8797	0.0010	0.0040	0.1121	0.0032
15		1	1	0.8957	0.0010	0.0039	0.0964	0.0030
16		1	1	0.8840	0.0010	0.0038	0.1083	0.0029
17		1	1	0.8948	0.0010	0.0039	0.0979	0.0024
18		1	1	0.9270	0.0010	0.0039	0.0672	0.0010
19		1	1	0.8661	0.0010	0.0025	0.1294	0.0010
20		1	1	0.9143	0.0010	0.0010	0.0827	0.0010
21		1	1	0.9020	0.0010	0.0010	0.0949	0.0011
22		1	1	0.9586	0.0010	0.0012	0.0383	0.0010
23		1	1	0.9668	0.0010	0.0010	0.0302	0.0010
24		1	1	0.9636	0.0010	0.0010	0.0334	0.0010
25		1	1	0.9634	0.0010	0.0010	0.0336	0.0010
26		1	1	0.7833	0.0010	0.0010	0.2137	0.0010
27		1	1	0.7072	0.0010	0.0010	0.2898	0.0010
28		1	1	0.8328	0.0017	0.0010	0.1635	0.0010
29		1	1	0.8499	0.0010	0.0010	0.1471	0.0010
30		1	1	0.8297	0.0010	0.0010	0.1673	0.0010
31		1	1	0.7769	0.0010	0.0010	0.2201	0.0010
32		1	1	0.7838	0.0010	0.0010	0.2132	0.0010
33		1	1	0.7676	0.0010	0.0010	0.2294	0.0010
34		1	1	0.7818	0.0010	0.0010	0.2152	0.0010
35	65	1	4	0 3677	0.0010	0.0010	0.6293	0.0010

36		4	4	0.2524	0.0010	0.0010	0.7446	0.0010
37		4	4	0.0835	0.0021	0.0010	0.9124	0.0010
38		4	4	0.0918	0.0018	0.0012	0.9043	0.0010
39		4	4	0.0903	0.0016	0.0012	0.9059	0.0010
40		4	4	0.1073	0.0010	0.0010	0.8896	0.0010
41		4	4	0.1377	0.0010	0.0010	0.8592	0.0011
42		4	4	0.0449	0.0010	0.0010	0.9521	0.0010
43		4	4	0.0366	0.0010	0.0010	0.9604	0.0010
44		4	4	0.0422	0.0011	0.0010	0.9544	0.0012
45		4	4	0.0261	0.0010	0.0013	0.9707	0.0010
46		4	4	0.0267	0.0010	0.0010	0.9703	0.0010
47		4	4	0.0325	0.0014	0.0014	0.9637	0.0010
48		4	4	0.0286	0.0010	0.0010	0.9684	0.0010
49		4	4	0.0345	0.0011	0.0015	0.9616	0.0014
50		4	4	0.0040	0.0010	0.0010	0.9930	0.0010
51		4	4	0.0037	0.0010	0.0011	0.9932	0.0010
52		4	4	0.0052	0.0010	0.0010	0.9918	0.0010
53		4	4	0.0114	0.0018	0.0010	0.9842	0.0016
54		4	4	0.0242	0.0026	0.0016	0.9687	0.0029
55		4	4	0.0343	0.0026	0.0021	0.9585	0.0025
56		4	4	0.0365	0.0040	0.0035	0.9515	0.0044
57		4	4	0.0411	0.0036	0.0035	0.9496	0.0022
58		4	4	0.0393	0.0038	0.0046	0.9498	0.0025
59		4	4	0.0276	0.0010	0.0019	0.9682	0.0013
60		4	4	0.0086	0.0010	0.0010	0.9884	0.0010
61		4	4	0.0174	0.0010	0.0018	0.9785	0.0012
62		4	4	0.0179	0.0010	0.0011	0.9790	0.0010
63		4	4	0.0369	0.0014	0.0029	0.9564	0.0024
64		4	4	0.0332	0.0252	0.0150	0.8690	0.0576
65	75	2	4	0.0195	0.1593	0.0631	0.4461	0.3120
66	75	2	5	0.0010	0.4098	0.0010	0.0010	0.5872
67		5	5	0.0010	0.3356	0.0035	0.0010	0.6590
68		5	5	0.0010	0.3215	0.0010	0.0010	0.6755
69		2	2	0.0010	0.5559	0.0010	0.0010	0.4411
70	75	2	5	0.0010	0.4815	0.0010	0.0010	0.5156
71		2	2	0.0010	0.8287	0.0010	0.0010	0.1683
72		2	2	0.0010	0.6490	0.0010	0.0010	0.3480
73		2	2	0.0010	0.8190	0.0010	0.0010	0.1780
74		2	2	0.0010	0.5772	0.0010	0.0010	0.4198
75	75	2	5	0.0010	0.4073	0.0010	0.0010	0.5898
76		5	5	0.0010	0.3273	0.0010	0.0010	0.6698

77	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
78	2	2	0.0010	0.9951	0.0012	0.0012	0.0015
79	2	2	0.0010	0.9919	0.0026	0.0018	0.0028
80	2	2	0.0010	0.9779	0.0052	0.0083	0.0076
81	2	2	0.0010	0.9666	0.0075	0.0143	0.0107
82	2	2	0.0010	0.9153	0.0159	0.0360	0.0318
83	2	2	0.0010	0.9293	0.0123	0.0397	0.0178
84	2	2	0.0010	0.6368	0.0829	0.2152	0.0642
85	2	2	0.0010	0.4783	0.1757	0.3338	0.0112
86	4	4	0.0010	0.2657	0.2497	0.4756	0.0079
87	4	4	0.0010	0.0358	0.3179	0.6433	0.0020
88	4	4	0.0010	0.0846	0.2057	0.7036	0.0052
89	4	4	0.0010	0.0866	0.3565	0.5512	0.0047
90	4	4	0.0010	0.1189	0.3146	0.5588	0.0067
91	4	4	0.0010	0.1587	0.2664	0.5636	0.0102
92	4	4	0.0010	0.1464	0.2845	0.5617	0.0064
93	4	4	0.0010	0.1372	0.2694	0.5855	0.0070
94	4	4	0.0010	0.0292	0.4605	0.5064	0.0029
95	3	3	0.0012	0.0093	0.6454	0.3407	0.0033
96	3	3	0.0022	0.0029	0.7360	0.2534	0.0054
97	3	3	0.0026	0.0026	0.8139	0.1715	0.0093
98	3	3	0.0021	0.0026	0.7897	0.1970	0.0086
99	3	3	0.0020	0.0021	0.8807	0.1108	0.0044
100	3	3	0.0029	0.0023	0.8315	0.1585	0.0049
101	3	3	0.0028	0.0023	0.8087	0.1825	0.0037
102	3	3	0.0026	0.0019	0.8099	0.1818	0.0037
103	3	3	0.0010	0.0010	0.9785	0.0185	0.0010
104	3	3	0.0011	0.0010	0.9905	0.0064	0.0010
105	3	3	0.0014	0.0010	0.9904	0.0063	0.0010
106	3	3	0.0046	0.0012	0.9824	0.0101	0.0017
107	3	3	0.0062	0.0016	0.9850	0.0055	0.0017
108	3	3	0.0098	0.0016	0.9811	0.0053	0.0023
109	3	3	0.0123	0.0015	0.9787	0.0048	0.0027
110	3	3	0.0252	0.0042	0.9614	0.0040	0.0051
111	3	3	0.0326	0.0042	0.9537	0.0034	0.0060
112	3	3	0.0321	0.0045	0.9553	0.0050	0.0031
113	3	3	0.0357	0.0098	0.9463	0.0070	0.0012
114	3	3	0.0386	0.0078	0.9472	0.0050	0.0014
115	3	3	0.0403	0.0086	0.9441	0.0059	0.0010
116	3	3	0.0430	0.0099	0.9412	0.0049	0.0010
117	3	3	0.0437	0.0090	0.9410	0.0052	0.0010

118		3	3	0.0253	0.0445	0.9159	0.0133	0.0010
119		3	3	0.0312	0.0373	0.9170	0.0135	0.0010
120		3	3	0.0177	0.0453	0.9297	0.0062	0.0010
121		3	3	0.0120	0.0483	0.9311	0.0076	0.0010
122		3	3	0.0105	0.0353	0.9462	0.0070	0.0010
123		3	3	0.0293	0.0229	0.9326	0.0135	0.0017
124		3	3	0.0304	0.0199	0.9355	0.0127	0.0016
125		3	3	0.0259	0.0259	0.9235	0.0237	0.0010
126		3	3	0.0181	0.0228	0.9334	0.0247	0.0010
127		3	3	0.0396	0.0382	0.8873	0.0335	0.0014
128		3	3	0.0109	0.0919	0.8660	0.0302	0.0010
129		3	3	0.0112	0.1845	0.7913	0.0109	0.0021
130		3	3	0.0112	0.1648	0.8108	0.0115	0.0017
131		3	3	0.0081	0.1661	0.8165	0.0081	0.0012
132		3	3	0.0033	0.2827	0.7099	0.0020	0.0021
133		3	3	0.0046	0.2465	0.7455	0.0024	0.0010
134		3	3	0.0018	0.3902	0.6060	0.0010	0.0010
135		3	3	0.0019	0.3448	0.6513	0.0010	0.0010
136		3	3	0.0010	0.4384	0.5585	0.0010	0.0012
137		3	3	0.0011	0.4047	0.5920	0.0010	0.0012
138		3	3	0.0010	0.4748	0.5219	0.0010	0.0013
139	55	3	2	0.0010	0.7036	0.2934	0.0010	0.0010
140	30	3	2	0.0010	0.5697	0.4270	0.0010	0.0013
141		2	2	0.0010	0.8529	0.1441	0.0010	0.0010
142		2	2	0.0020	0.7846	0.2108	0.0010	0.0016
143	55	3	2	0.0032	0.7421	0.2512	0.0013	0.0023
144	55	3	2	0.0028	0.7094	0.2843	0.0012	0.0023
145	55	3	2	0.0026	0.7031	0.2908	0.0011	0.0024
146	30	3	2	0.0035	0.6033	0.3892	0.0015	0.0025
147		3	3	0.0048	0.4430	0.5466	0.0022	0.0035
148		3	3	0.0072	0.4396	0.5460	0.0024	0.0048
149		3	3	0.0094	0.3803	0.6027	0.0024	0.0052
150		3	3	0.0114	0.0618	0.9191	0.0045	0.0032
151		3	3	0.0191	0.0157	0.9561	0.0073	0.0018
152		3	3	0.0191	0.0192	0.9472	0.0130	0.0016
153		3	3	0.0201	0.0482	0.8595	0.0707	0.0015
154		3	3	0.0214	0.0234	0.8869	0.0672	0.0012
155		3	3	0.0522	0.1011	0.6933	0.1517	0.0017
156		3	3	0.0550	0.0811	0.7430	0.1188	0.0021
157		3	3	0.0561	0.1619	0.6586	0.1194	0.0040
158		3	3	0.0537	0.1413	0.6727	0.1276	0.0047

159	3	3	0.0616	0.2012	0.6202	0.1096	0.0074
160	3	3	0.0942	0.2144	0.5228	0.1669	0.0017
161	3	3	0.1233	0.1618	0.5217	0.1917	0.0015
162	4	4	0.0281	0.0193	0.4322	0.5194	0.0010
163	3	3	0.0209	0.0075	0.6553	0.3150	0.0013
164	3	3	0.0442	0.0062	0.7450	0.2015	0.0031
165	3	3	0.0766	0.0035	0.7875	0.1265	0.0059
166	3	3	0.0731	0.0028	0.7959	0.1242	0.0041
167	3	3	0.0685	0.0017	0.7964	0.1316	0.0018
168	3	3	0.0323	0.0018	0.8202	0.1447	0.0010
169	3	3	0.0265	0.0015	0.8256	0.1454	0.0010
170	3	3	0.0326	0.0010	0.8095	0.1558	0.0010
171	3	3	0.0010	0.0023	0.6879	0.3078	0.0010
172	3	3	0.0028	0.0019	0.5068	0.4872	0.0014
173	3	3	0.0059	0.0020	0.5602	0.4293	0.0026
174	3	3	0.0104	0.0030	0.5958	0.3846	0.0063
175	3	3	0.0119	0.0025	0.5609	0.4175	0.0072
176	3	3	0.0167	0.0027	0.5053	0.4655	0.0098
177	3	3	0.0159	0.0034	0.5335	0.4383	0.0089
178	3	3	0.0130	0.0037	0.4874	0.4871	0.0090
179	3	3	0.0144	0.0042	0.5873	0.3829	0.0112
180	3	3	0.0226	0.0016	0.5086	0.4595	0.0078
181	4	4	0.0216	0.0010	0.4712	0.5011	0.0051
182	4	4	0.0231	0.0010	0.4076	0.5631	0.0052
183	4	4	0.0294	0.0010	0.4334	0.5320	0.0042
184	4	4	0.0346	0.0010	0.3993	0.5620	0.0031
185	4	4	0.0280	0.0010	0.3526	0.6168	0.0015
186	4	4	0.0176	0.0044	0.2078	0.7675	0.0027
187	4	4	0.0203	0.0030	0.2006	0.7742	0.0020
188	4	4	0.0152	0.0040	0.1839	0.7945	0.0024
189	4	4	0.0036	0.0040	0.1432	0.8482	0.0010
190	4	4	0.0049	0.0038	0.1501	0.8401	0.0011
191	4	4	0.0078	0.0012	0.1976	0.7924	0.0010
192	4	4	0.0087	0.0015	0.2377	0.7508	0.0013
193	4	4	0.0044	0.0010	0.1400	0.8536	0.0010
194	4	4	0.0042	0.0010	0.1200	0.8738	0.0010
195	4	4	0.0066	0.0010	0.0796	0.9116	0.0012
196	4	4	0.0035	0.0026	0.0396	0.9533	0.0010
197	4	4	0.0030	0.0023	0.0294	0.9632	0.0020
198	4	4	0.0041	0.0018	0.0233	0.9689	0.0019
199	4	4	0.0040	0.0017	0.0220	0.9707	0.0016

200	4	4	0.0032	0.0021	0.0092	0.9838	0.0017
201	4	4	0.0035	0.0020	0.0094	0.9836	0.0014
202	4	4	0.0050	0.0026	0.0102	0.9801	0.0020
203	4	4	0.0059	0.0024	0.0107	0.9787	0.0022
204	4	4	0.0053	0.0022	0.0105	0.9801	0.0020
205	4	4	0.0064	0.0020	0.0100	0.9798	0.0018
206	4	4	0.0069	0.0024	0.0073	0.9809	0.0026
207	4	4	0.0081	0.0033	0.0078	0.9764	0.0045
208	4	4	0.0104	0.0030	0.0087	0.9729	0.0050
209	4	4	0.0097	0.0091	0.0146	0.9529	0.0137
210	4	4	0.0099	0.0074	0.0144	0.9551	0.0131
211	4	4	0.0101	0.0067	0.0096	0.9654	0.0082
212	4	4	0.0049	0.0062	0.0071	0.9766	0.0052
213	4	4	0.0051	0.0065	0.0058	0.9763	0.0063
214	4	4	0.0065	0.0058	0.0053	0.9755	0.0069
215	4	4	0.0055	0.0047	0.0055	0.9819	0.0024
216	4	4	0.0072	0.0037	0.0051	0.9825	0.0014
217	4	4	0.0108	0.0034	0.0056	0.9787	0.0015
218	4	4	0.0115	0.0013	0.0107	0.9755	0.0010
219	4	4	0.0148	0.0010	0.0050	0.9782	0.0010
220	4	4	0.0114	0.0010	0.0043	0.9823	0.0010
221	4	4	0.0060	0.0010	0.0028	0.9892	0.0010
222	4	4	0.0070	0.0010	0.0027	0.9882	0.0010
223	4	4	0.0065	0.0010	0.0033	0.9882	0.0010
224	4	4	0.0090	0.0010	0.0025	0.9865	0.0010
225	4	4	0.0062	0.0010	0.0017	0.9901	0.0010
226	4	4	0.0062	0.0019	0.0021	0.9875	0.0022
227	4	4	0.0079	0.0026	0.0019	0.9842	0.0035
228	4	4	0.0102	0.0028	0.0014	0.9825	0.0030
229	4	4	0.0141	0.0015	0.0016	0.9792	0.0036
230	4	4	0.0017	0.0031	0.0010	0.9932	0.0010
231	4	4	0.0017	0.0035	0.0010	0.9927	0.0010
232	4	4	0.0023	0.0032	0.0010	0.9924	0.0012
233	4	4	0.0023	0.0033	0.0010	0.9924	0.0010
234	4	4	0.0026	0.0028	0.0010	0.9926	0.0010
235	4	4	0.0034	0.0021	0.0010	0.9926	0.0010
236	4	4	0.0048	0.0021	0.0012	0.9907	0.0012
237	4	4	0.0053	0.0020	0.0013	0.9902	0.0012
238	4	4	0.0066	0.0013	0.0014	0.9894	0.0012
239	4	4	0.0143	0.0010	0.0120	0.9696	0.0032
240	4	4	0.0345	0.0010	0.0236	0.9359	0.0050

E.5 KREST Results from Trajectory Five Residuals.

KREST: Kalman filter Expert SysTem.
NFRMS: 240
ITraj: 5

#	Rule	KR	MAP	P1	P2	P3	P4	P5
1		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
2		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
3		1	1	0.9605	0.0092	0.0100	0.0103	0.0099
4		1	1	0.9644	0.0014	0.0091	0.0178	0.0073
5		1	1	0.9046	0.0040	0.0140	0.0676	0.0098
6		1	1	0.8829	0.0051	0.0122	0.0900	0.0099
7		1	1	0.8849	0.0014	0.0082	0.0967	0.0087
8		1	1	0.8909	0.0013	0.0079	0.0918	0.0081
9		1	1	0.9001	0.0010	0.0077	0.0841	0.0071
10		1	1	0.9025	0.0013	0.0068	0.0812	0.0082
11		1	1	0.8835	0.0010	0.0070	0.1001	0.0084
12		1	1	0.8835	0.0010	0.0059	0.1036	0.0060
13		1	1	0.8625	0.0010	0.0053	0.1255	0.0057
14		1	1	0.8797	0.0010	0.0040	0.1121	0.0032
15		1	1	0.8957	0.0010	0.0039	0.0964	0.0030
16		1	1	0.8840	0.0010	0.0038	0.1083	0.0029
17		1	1	0.8948	0.0010	0.0039	0.0979	0.0024
18		1	1	0.9270	0.0010	0.0039	0.0672	0.0010
19		1	1	0.8661	0.0010	0.0025	0.1294	0.0010
20		1	1	0.9143	0.0010	0.0010	0.0827	0.0010
21		1	1	0.9020	0.0010	0.0010	0.0949	0.0011
22		1	1	0.9586	0.0010	0.0012	0.0383	0.0010
23		1	1	0.9668	0.0010	0.0010	0.0302	0.0010
24		1	1	0.9636	0.0010	0.0010	0.0334	0.0010
25		1	1	0.9634	0.0010	0.0010	0.0336	0.0010
26		1	1	0.7833	0.0010	0.0010	0.2137	0.0010
27		1	1	0.7072	0.0010	0.0010	0.2898	0.0010
28		1	1	0.8328	0.0017	0.0010	0.1635	0.0010
29		1	1	0.8499	0.0010	0.0010	0.1471	0.0010
30		1	1	0.8297	0.0010	0.0010	0.1673	0.0010
31		1	1	0.7769	0.0010	0.0010	0.2201	0.0010
32		1	1	0.7838	0.0010	0.0010	0.2132	0.0010
33		1	1	0.7676	0.0010	0.0010	0.2294	0.0010
34		1	1	0.7818	0.0010	0.0010	0.2152	0.0010
35	65	1	4	0.3677	0.0010	0.0010	0.6293	0.0010

36		4	4	0.2524	0.0010	0.0010	0.7446	0.0010
37		4	4	0.0835	0.0021	0.0010	0.9124	0.0010
38		4	4	0.0918	0.0018	0.0012	0.9043	0.0010
39		4	4	0.0903	0.0016	0.0012	0.9059	0.0010
40		4	4	0.1073	0.0010	0.0010	0.8896	0.0010
41		4	4	0.1377	0.0010	0.0010	0.8592	0.0011
42		4	4	0.0449	0.0010	0.0010	0.9521	0.0010
43		4	4	0.0366	0.0010	0.0010	0.9604	0.0010
44		4	4	0.0422	0.0011	0.0010	0.9544	0.0012
45		4	4	0.0261	0.0010	0.0013	0.9707	0.0010
46		4	4	0.0267	0.0010	0.0010	0.9703	0.0010
47		4	4	0.0325	0.0014	0.0014	0.9637	0.0010
48		4	4	0.0286	0.0010	0.0010	0.9684	0.0010
49		4	4	0.0345	0.0011	0.0015	0.9616	0.0014
50		4	4	0.0040	0.0010	0.0010	0.9930	0.0010
51		4	4	0.0037	0.0010	0.0011	0.9932	0.0010
52		4	4	0.0052	0.0010	0.0010	0.9918	0.0010
53		4	4	0.0114	0.0018	0.0010	0.9842	0.0016
54		4	4	0.0242	0.0026	0.0016	0.9687	0.0029
55		4	4	0.0343	0.0026	0.0021	0.9585	0.0025
56		4	4	0.0365	0.0040	0.0035	0.9515	0.0044
57		4	4	0.0411	0.0036	0.0035	0.9496	0.0022
58		4	4	0.0393	0.0038	0.0046	0.9498	0.0025
59		4	4	0.0276	0.0010	0.0019	0.9682	0.0013
60		4	4	0.0086	0.0010	0.0010	0.9884	0.0010
61		4	4	0.0174	0.0010	0.0018	0.9785	0.0012
62		4	4	0.0179	0.0010	0.0011	0.9790	0.0010
63		4	4	0.0369	0.0014	0.0029	0.9564	0.0024
64		4	4	0.0332	0.0252	0.0150	0.8690	0.0576
65	75	2	4	0.0194	0.1596	0.0631	0.4463	0.3115
66	75	2	5	0.0010	0.4115	0.0010	0.0010	0.5855
67		5	5	0.0010	0.3375	0.0035	0.0010	0.6571
68		5	5	0.0010	0.3250	0.0010	0.0010	0.6720
69		2	2	0.0010	0.5609	0.0010	0.0010	0.4361
70		2	2	0.0010	0.5193	0.0010	0.0010	0.4777
71		2	2	0.0010	0.5114	0.0010	0.0010	0.4856
72		5	5	0.0010	0.2619	0.0010	0.0010	0.7351
73		2	2	0.0010	0.5050	0.0010	0.0010	0.4920
74		5	5	0.0010	0.2334	0.0010	0.0010	0.7636
75		5	5	0.0010	0.1971	0.0010	0.0010	0.7999
76		2	2	0.0010	0.9960	0.0010	0.0010	0.0010

77		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
78		2	2	0.0014	0.9941	0.0014	0.0015	0.0016
79		2	2	0.0021	0.9899	0.0028	0.0024	0.0028
80		2	2	0.0057	0.9721	0.0059	0.0084	0.0079
81		2	2	0.0093	0.9582	0.0082	0.0129	0.0114
82		2	2	0.0245	0.8937	0.0176	0.0352	0.0292
83		2	2	0.0190	0.9005	0.0138	0.0409	0.0258
84		2	2	0.1003	0.5316	0.0794	0.2063	0.0824
85	75	2	4	0.1452	0.3067	0.1334	0.4017	0.0130
86	70	1	4	0.1871	0.1637	0.1797	0.4611	0.0085
87	70	1	4	0.2382	0.0168	0.1750	0.5682	0.0018
88		4	4	0.2123	0.0398	0.0877	0.6556	0.0045
89	25	1	4	0.3316	0.0348	0.1385	0.4915	0.0035
90	25	1	4	0.3501	0.0445	0.1168	0.4838	0.0047
91	25	1	4	0.3705	0.0556	0.0992	0.4680	0.0068
92	25	1	4	0.3949	0.0492	0.1016	0.4493	0.0050
93	25	1	4	0.3991	0.0449	0.0975	0.4531	0.0054
94	25	1	4	0.4310	0.0052	0.0689	0.4939	0.0010
95		1	1	0.6342	0.0010	0.0811	0.2827	0.0010
96		1	1	0.7714	0.0010	0.0491	0.1771	0.0014
97		1	1	0.8393	0.0010	0.0397	0.1182	0.0018
98		1	1	0.8556	0.0010	0.0335	0.1082	0.0017
99		1	1	0.9089	0.0010	0.0329	0.0562	0.0010
100		1	1	0.8991	0.0011	0.0289	0.0696	0.0013
101		1	1	0.9223	0.0010	0.0203	0.0554	0.0010
102		1	1	0.9280	0.0010	0.0176	0.0524	0.0010
103		1	1	0.9232	0.0010	0.0725	0.0023	0.0010
104		1	1	0.9431	0.0010	0.0539	0.0010	0.0010
105		1	1	0.9479	0.0010	0.0491	0.0010	0.0010
106		1	1	0.9612	0.0010	0.0358	0.0010	0.0010
107		1	1	0.9564	0.0011	0.0403	0.0010	0.0011
108		1	1	0.9655	0.0010	0.0315	0.0010	0.0010
109		1	1	0.9631	0.0010	0.0339	0.0010	0.0010
110		1	1	0.9614	0.0010	0.0354	0.0012	0.0010
111		1	1	0.7283	0.0103	0.2443	0.0011	0.0160
112	45	2	5	0.0086	0.1135	0.3011	0.0010	0.5758
113		2	2	0.0010	0.8840	0.0874	0.0010	0.0265
114		2	2	0.0010	0.9270	0.0432	0.0010	0.0278
115		2	2	0.0010	0.9513	0.0030	0.0010	0.0438
116		2	2	0.0010	0.9262	0.0048	0.0010	0.0670
117		2	2	0.0010	0.9198	0.0021	0.0010	0.0761

118		2	2	0.0010	0.8522	0.0023	0.0010	0.1435
119		2	2	0.0010	0.9201	0.0018	0.0010	0.0761
120		2	2	0.0010	0.9271	0.0097	0.0010	0.0612
121		2	2	0.0010	0.8382	0.0275	0.0010	0.1323
122		2	2	0.0010	0.8268	0.0152	0.0010	0.1560
123		2	2	0.0010	0.9464	0.0150	0.0010	0.0366
124		2	2	0.0010	0.9529	0.0193	0.0010	0.0259
125		2	2	0.0010	0.7492	0.1615	0.0010	0.0873
126	55	3	2	0.0010	0.5822	0.2804	0.0010	0.1354
127	55	3	2	0.0010	0.5304	0.4445	0.0010	0.0231
128	55	3	2	0.0010	0.5449	0.3956	0.0010	0.0575
129	30	3	2	0.0010	0.5924	0.3556	0.0010	0.0500
130		3	3	0.0010	0.2277	0.7148	0.0010	0.0556
131		3	3	0.0010	0.1191	0.8445	0.0010	0.0344
132		3	3	0.0010	0.1939	0.7683	0.0010	0.0357
133		3	3	0.0010	0.1187	0.8657	0.0010	0.0136
134		3	3	0.0012	0.1320	0.8500	0.0010	0.0159
135		3	3	0.0010	0.1202	0.8690	0.0010	0.0088
136		3	3	0.0010	0.1325	0.8611	0.0010	0.0044
137		3	3	0.0010	0.1275	0.8667	0.0010	0.0038
138		3	3	0.0013	0.1152	0.8790	0.0010	0.0035
139		3	3	0.0014	0.2264	0.7633	0.0015	0.0075
140		3	3	0.0014	0.2154	0.7762	0.0017	0.0053
141		3	3	0.0010	0.0514	0.9376	0.0065	0.0036
142		3	3	0.0017	0.0143	0.9739	0.0066	0.0036
143		3	3	0.0052	0.0244	0.9496	0.0117	0.0091
144		3	3	0.0038	0.0185	0.9595	0.0105	0.0078
145		3	3	0.0039	0.0161	0.9630	0.0099	0.0072
146		3	3	0.0036	0.0162	0.9633	0.0113	0.0056
147		3	3	0.0040	0.0172	0.9591	0.0150	0.0048
148		3	3	0.0047	0.0247	0.9479	0.0170	0.0057
149		3	3	0.0054	0.0202	0.9517	0.0169	0.0058
150		3	3	0.0127	0.0011	0.9540	0.0298	0.0023
151		3	3	0.0139	0.0010	0.9615	0.0226	0.0010
152		3	3	0.0290	0.0039	0.8307	0.1342	0.0022
153		3	3	0.0374	0.0021	0.8202	0.1380	0.0022
154		3	3	0.0498	0.0020	0.7895	0.1571	0.0016
155		3	3	0.0475	0.0037	0.7082	0.2396	0.0010
156		3	3	0.0461	0.0031	0.7863	0.1630	0.0015
157		3	3	0.0204	0.0045	0.8043	0.1692	0.0016
158		3	3	0.0195	0.0043	0.8521	0.1225	0.0015

159	3	3	0.0179	0.0044	0.8583	0.1176	0.0018
160	3	3	0.0329	0.0038	0.7195	0.2428	0.0010
161	3	3	0.0407	0.0028	0.6369	0.3186	0.0010
162	3	3	0.0010	0.0010	0.6815	0.3155	0.0010
163	3	3	0.0010	0.0010	0.8439	0.1531	0.0010
164	3	3	0.0027	0.0010	0.9245	0.0693	0.0025
165	3	3	0.0059	0.0010	0.9398	0.0490	0.0043
166	3	3	0.0067	0.0010	0.9349	0.0540	0.0033
167	3	3	0.0061	0.0011	0.9194	0.0708	0.0027
168	3	3	0.0030	0.0013	0.9319	0.0627	0.0011
169	3	3	0.0028	0.0011	0.9365	0.0587	0.0010
170	3	3	0.0031	0.0010	0.9393	0.0556	0.0010
171	3	3	0.0010	0.0010	0.7560	0.2410	0.0010
172	4	4	0.0036	0.0010	0.3871	0.6061	0.0022
173	4	4	0.0072	0.0010	0.4308	0.5581	0.0029
174	4	4	0.0158	0.0010	0.4373	0.5419	0.0040
175	4	4	0.0177	0.0010	0.4128	0.5643	0.0041
176	4	4	0.0210	0.0011	0.3671	0.6089	0.0019
177	4	4	0.0155	0.0011	0.2894	0.6927	0.0013
178	4	4	0.0120	0.0010	0.2353	0.7508	0.0010
179	4	4	0.0104	0.0010	0.2325	0.7551	0.0010
180	4	4	0.0091	0.0010	0.1698	0.8187	0.0014
181	4	4	0.0062	0.0010	0.1598	0.8320	0.0010
182	4	4	0.0074	0.0011	0.0906	0.8998	0.0011
183	4	4	0.0135	0.0010	0.1491	0.8344	0.0021
184	4	4	0.0153	0.0010	0.1486	0.8333	0.0018
185	4	4	0.0172	0.0010	0.1869	0.7930	0.0020
186	4	4	0.0082	0.0010	0.1101	0.8797	0.0010
187	4	4	0.0099	0.0010	0.1108	0.8773	0.0010
188	4	4	0.0087	0.0010	0.1149	0.8742	0.0012
189	4	4	0.0023	0.0010	0.0573	0.9384	0.0010
190	4	4	0.0031	0.0011	0.0538	0.9407	0.0012
191	4	4	0.0056	0.0010	0.0768	0.9142	0.0024
192	4	4	0.0078	0.0025	0.1527	0.8308	0.0063
193	4	4	0.0042	0.0010	0.1079	0.8822	0.0047
194	4	4	0.0045	0.0010	0.1008	0.8907	0.0030
195	4	4	0.0067	0.0010	0.1009	0.8881	0.0032
196	4	4	0.0022	0.0010	0.0378	0.9580	0.0010
197	4	4	0.0034	0.0015	0.0370	0.9567	0.0014
198	4	4	0.0042	0.0011	0.0275	0.9659	0.0012
199	4	4	0.0039	0.0010	0.0265	0.9675	0.0011

200	4	4	0.0034	0.0011	0.0191	0.9754	0.0010
201	4	4	0.0047	0.0010	0.0148	0.9785	0.0010
202	4	4	0.0053	0.0010	0.0146	0.9781	0.0010
203	4	4	0.0073	0.0010	0.0154	0.9750	0.0012
204	4	4	0.0072	0.0010	0.0108	0.9800	0.0010
205	4	4	0.0065	0.0010	0.0081	0.9834	0.0010
206	4	4	0.0054	0.0010	0.0053	0.9873	0.0010
207	4	4	0.0070	0.0010	0.0052	0.9853	0.0014
208	4	4	0.0080	0.0010	0.0055	0.9842	0.0012
209	4	4	0.0096	0.0015	0.0057	0.9822	0.0011
210	4	4	0.0093	0.0013	0.0054	0.9829	0.0011
211	4	4	0.0074	0.0010	0.0033	0.9874	0.0010
212	4	4	0.0028	0.0010	0.0017	0.9935	0.0010
213	4	4	0.0027	0.0010	0.0014	0.9939	0.0010
214	4	4	0.0029	0.0010	0.0011	0.9940	0.0010
215	4	4	0.0024	0.0015	0.0014	0.9937	0.0010
216	4	4	0.0030	0.0013	0.0014	0.9933	0.0010
217	4	4	0.0041	0.0013	0.0016	0.9919	0.0011
218	4	4	0.0077	0.0017	0.0060	0.9818	0.0027
219	4	4	0.0092	0.0010	0.0041	0.9846	0.0010
220	4	4	0.0078	0.0010	0.0028	0.9875	0.0010
221	4	4	0.0036	0.0010	0.0017	0.9927	0.0010
222	4	4	0.0044	0.0010	0.0017	0.9918	0.0011
223	4	4	0.0057	0.0019	0.0034	0.9870	0.0020
224	4	4	0.0066	0.0013	0.0026	0.9882	0.0013
225	4	4	0.0057	0.0012	0.0020	0.9900	0.0011
226	4	4	0.0139	0.0058	0.0051	0.9725	0.0027
227	4	4	0.0155	0.0050	0.0042	0.9721	0.0031
228	4	4	0.0158	0.0024	0.0018	0.9791	0.0010
229	4	4	0.0216	0.0024	0.0021	0.9727	0.0011
230	4	4	0.0041	0.0046	0.0010	0.9894	0.0010
231	4	4	0.0037	0.0015	0.0010	0.9928	0.0010
232	4	4	0.0037	0.0010	0.0010	0.9933	0.0010
233	4	4	0.0076	0.0020	0.0010	0.9879	0.0015
234	4	4	0.0085	0.0014	0.0010	0.9879	0.0013
235	4	4	0.0106	0.0016	0.0012	0.9849	0.0017
236	4	4	0.0133	0.0016	0.0013	0.9820	0.0019
237	4	4	0.0137	0.0015	0.0013	0.9813	0.0022
238	4	4	0.0148	0.0012	0.0013	0.9811	0.0016
239	4	4	0.0051	0.0010	0.0013	0.9916	0.0010
240	4	4	0.0060	0.0010	0.0010	0.9910	0.0010

E.6 KREST Results from Trajectory Six Residuals.

KREST: Kalman filter Expert SysTem.
NFRMS: 240
ITraj: 6

#	Rule	KR	MAP	P1	P2	P3	P4	P5
1		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
2		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
3		1	1	0.9605	0.0092	0.0100	0.0103	0.0099
4		1	1	0.9644	0.0014	0.0091	0.0178	0.0073
5		1	1	0.9046	0.0040	0.0140	0.0676	0.0098
6		1	1	0.8829	0.0051	0.0122	0.0900	0.0099
7		1	1	0.8849	0.0014	0.0082	0.0967	0.0087
8		1	1	0.8909	0.0013	0.0079	0.0918	0.0081
9		1	1	0.9001	0.0010	0.0077	0.0841	0.0071
10		1	1	0.9025	0.0013	0.0068	0.0812	0.0082
11		1	1	0.8835	0.0010	0.0070	0.1001	0.0084
12		1	1	0.8835	0.0010	0.0059	0.1036	0.0060
13		1	1	0.8625	0.0010	0.0053	0.1255	0.0057
14		1	1	0.8797	0.0010	0.0040	0.1121	0.0032
15		1	1	0.8957	0.0010	0.0039	0.0964	0.0030
16		1	1	0.8840	0.0010	0.0038	0.1083	0.0029
17		1	1	0.8948	0.0010	0.0039	0.0979	0.0024
18		1	1	0.9270	0.0010	0.0039	0.0672	0.0010
19		1	1	0.8661	0.0010	0.0025	0.1294	0.0010
20		1	1	0.9143	0.0010	0.0010	0.0827	0.0010
21		1	1	0.9020	0.0010	0.0010	0.0949	0.0011
22		1	1	0.9586	0.0010	0.0012	0.0383	0.0010
23		1	1	0.9668	0.0010	0.0010	0.0302	0.0010
24		1	1	0.9636	0.0010	0.0010	0.0334	0.0010
25		1	1	0.9634	0.0010	0.0010	0.0336	0.0010
26		1	1	0.7833	0.0010	0.0010	0.2137	0.0010
27		1	1	0.7072	0.0010	0.0010	0.2898	0.0010
28		1	1	0.8328	0.0017	0.0010	0.1635	0.0010
29		1	1	0.8499	0.0010	0.0010	0.1471	0.0010
30		1	1	0.8297	0.0010	0.0010	0.1673	0.0010
31		1	1	0.7769	0.0010	0.0010	0.2201	0.0010
32		1	1	0.7838	0.0010	0.0010	0.2132	0.0010
33		1	1	0.7676	0.0010	0.0010	0.2294	0.0010
34		1	1	0.7818	0.0010	0.0010	0.2152	0.0010
35	65	1	4	0.3677	0.0010	0.0010	0.6293	0.0010

36	4	4	0.2524	0.0010	0.0010	0.7446	0.0010
37	4	4	0.0835	0.0021	0.0010	0.9124	0.0010
38	4	4	0.0918	0.0018	0.0012	0.9043	0.0010
39	4	4	0.0903	0.0016	0.0012	0.9059	0.0010
40	4	4	0.1073	0.0010	0.0010	0.8896	0.0010
41	4	4	0.1377	0.0010	0.0010	0.8592	0.0011
42	4	4	0.0449	0.0010	0.0010	0.9521	0.0010
43	4	4	0.0366	0.0010	0.0010	0.9604	0.0010
44	4	4	0.0422	0.0011	0.0010	0.9544	0.0012
45	4	4	0.0261	0.0010	0.0013	0.9707	0.0010
46	4	4	0.0267	0.0010	0.0010	0.9703	0.0010
47	4	4	0.0325	0.0014	0.0014	0.9637	0.0010
48	4	4	0.0286	0.0010	0.0010	0.9684	0.0010
49	4	4	0.0345	0.0011	0.0015	0.9616	0.0014
50	4	4	0.0040	0.0010	0.0010	0.9930	0.0010
51	4	4	0.0037	0.0010	0.0011	0.9932	0.0010
52	4	4	0.0052	0.0010	0.0010	0.9918	0.0010
53	4	4	0.0114	0.0018	0.0010	0.9842	0.0016
54	4	4	0.0242	0.0026	0.0016	0.9687	0.0029
55	4	4	0.0343	0.0026	0.0021	0.9585	0.0025
56	4	4	0.0365	0.0040	0.0035	0.9515	0.0044
57	4	4	0.0411	0.0036	0.0035	0.9496	0.0022
58	4	4	0.0393	0.0038	0.0046	0.9498	0.0025
59	4	4	0.0276	0.0010	0.0019	0.9682	0.0013
60	4	4	0.0086	0.0010	0.0010	0.9884	0.0010
61	4	4	0.0174	0.0010	0.0018	0.9785	0.0012
62	4	4	0.0181	0.0012	0.0019	0.9774	0.0014
63	4	4	0.0016	0.1910	0.0042	0.7911	0.0121
64	2	2	0.0010	0.9633	0.0091	0.0037	0.0229
65	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
66	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
67	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
68	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
69	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
70	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
71	2	2	0.0725	0.9010	0.0010	0.0010	0.0245
72	2	2	0.0143	0.9825	0.0010	0.0012	0.0010
73	1	1	0.5997	0.0667	0.0010	0.0077	0.3249
74	1	1	0.6298	0.0343	0.0010	0.0051	0.3299
75	1	1	0.6247	0.0365	0.0010	0.0051	0.3328
76	1	1	0.6282	0.0362	0.0010	0.0055	0.3290

77		1	1	0.7124	0.0129	0.0010	0.0074	0.2664
78		1	1	0.7061	0.0119	0.0010	0.0085	0.2725
79		1	1	0.6938	0.0127	0.0010	0.0086	0.2839
80		1	1	0.7899	0.0026	0.0010	0.0118	0.1947
81		1	1	0.8115	0.0010	0.0010	0.0122	0.1744
82		1	1	0.8880	0.0010	0.0010	0.0138	0.0962
83		1	1	0.9081	0.0010	0.0010	0.0135	0.0764
84		1	1	0.9238	0.0010	0.0010	0.0142	0.0599
85		1	1	0.9383	0.0010	0.0010	0.0145	0.0452
86		1	1	0.9675	0.0010	0.0019	0.0116	0.0180
87		1	1	0.9801	0.0010	0.0010	0.0152	0.0027
88		1	1	0.9771	0.0010	0.0010	0.0185	0.0024
89		1	1	0.9588	0.0022	0.0010	0.0351	0.0029
90		1	1	0.9624	0.0031	0.0010	0.0276	0.0059
91		1	1	0.9436	0.0078	0.0010	0.0330	0.0145
92		1	1	0.9593	0.0067	0.0010	0.0234	0.0095
93		1	1	0.9532	0.0103	0.0011	0.0193	0.0162
94		1	1	0.4201	0.0881	0.0012	0.2036	0.2870
95	70	1	5	0.3367	0.0850	0.0020	0.2081	0.3682
96	70	1	5	0.3114	0.0404	0.0023	0.0707	0.5753
97		5	5	0.1421	0.0692	0.0027	0.0345	0.7516
98		5	5	0.0450	0.2350	0.0031	0.0284	0.6886
99		5	5	0.0058	0.2710	0.0020	0.0059	0.7153
100		5	5	0.0013	0.2254	0.0014	0.0019	0.7700
101		2	2	0.0010	0.6581	0.0010	0.0029	0.3371
102		2	2	0.0010	0.9251	0.0010	0.0040	0.0689
103		2	2	0.0010	0.9952	0.0010	0.0010	0.0018
104		2	2	0.0010	0.9926	0.0034	0.0017	0.0013
105		2	2	0.0010	0.9955	0.0015	0.0010	0.0010
106		2	2	0.0010	0.9952	0.0016	0.0010	0.0012
107		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
108		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
109		2	2	0.0010	0.9957	0.0013	0.0010	0.0010
110		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
111		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
112		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
113		2	2	0.0010	0.9934	0.0019	0.0010	0.0027
114		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
115		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
116		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
117		2	2	0.0010	0.9960	0.0010	0.0010	0.0010

118	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
119	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
120	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
121	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
122	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
123	2	2	0.0010	0.9955	0.0012	0.0013	0.0010
124	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
125	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
126	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
127	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
128	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
129	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
130	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
131	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
132	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
133	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
134	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
135	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
136	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
137	2	2	0.0095	0.9751	0.0060	0.0060	0.0033
138	2	2	0.0373	0.9303	0.0123	0.0158	0.0043
139	2	2	0.0217	0.9370	0.0108	0.0293	0.0012
140	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
141	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
142	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
143	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
144	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
145	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
146	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
147	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
148	2	2	0.0014	0.9953	0.0010	0.0010	0.0013
149	2	2	0.0020	0.9936	0.0010	0.0013	0.0021
150	2	2	0.0014	0.9956	0.0010	0.0010	0.0010
151	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
152	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
153	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
154	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
155	2	2	0.0010	0.9932	0.0038	0.0010	0.0010
156	2	2	0.0010	0.9908	0.0059	0.0010	0.0014
157	2	2	0.0018	0.9805	0.0133	0.0020	0.0025
158	2	2	0.0016	0.9822	0.0123	0.0011	0.0028

159		2	2	0.0022	0.9763	0.0157	0.0014	0.0043
160		2	2	0.0049	0.9547	0.0322	0.0028	0.0054
161		2	2	0.0147	0.8685	0.0966	0.0080	0.0122
162		2	2	0.0030	0.8383	0.0252	0.1118	0.0216
163		2	2	0.0042	0.8624	0.0283	0.0793	0.0257
164		2	2	0.0080	0.7856	0.0463	0.1189	0.0413
165		2	2	0.0133	0.7520	0.0669	0.0801	0.0876
166		2	2	0.0177	0.7229	0.0698	0.0973	0.0923
167		2	2	0.0206	0.6913	0.0694	0.1165	0.1022
168		2	2	0.0265	0.5938	0.0977	0.0971	0.1849
169		2	2	0.0335	0.5847	0.1084	0.1072	0.1662
170		2	2	0.0413	0.5476	0.1182	0.1144	0.1785
171		2	2	0.0067	0.7394	0.0553	0.1246	0.0740
172		2	2	0.0198	0.5772	0.0753	0.1503	0.1775
173		2	2	0.0384	0.4798	0.0996	0.1556	0.2265
174		2	2	0.0498	0.4274	0.0755	0.1618	0.2855
175		2	2	0.0686	0.4341	0.0873	0.1543	0.2557
176		2	2	0.0759	0.3583	0.0858	0.2059	0.2741
177		2	2	0.0710	0.3692	0.0720	0.2422	0.2456
178		2	2	0.0630	0.3718	0.0807	0.3061	0.1785
179		2	2	0.0863	0.3776	0.0949	0.2644	0.1768
180		2	2	0.1309	0.3852	0.0854	0.1769	0.2216
181		2	2	0.1512	0.3817	0.0943	0.1832	0.1895
182		2	2	0.1896	0.3581	0.0678	0.1747	0.2097
183	75	2	5	0.2119	0.2678	0.0668	0.1668	0.2867
184	70	1	5	0.2553	0.2142	0.0640	0.1738	0.2928
185	75	2	5	0.1585	0.2224	0.0541	0.1656	0.3994
186	75	2	5	0.1329	0.2762	0.0319	0.2478	0.3111
187	75	2	5	0.1770	0.2348	0.0333	0.2366	0.3183
188	70	1	5	0.2126	0.1670	0.0413	0.2763	0.3029
189	75	2	4	0.0848	0.2058	0.0256	0.5446	0.1392
190	70	1	4	0.1304	0.1204	0.0254	0.5376	0.1862
191	70	1	5	0.1269	0.0619	0.0149	0.3489	0.4475
192		5	5	0.0525	0.0860	0.0152	0.1034	0.7430
193		5	5	0.0521	0.1376	0.0200	0.1296	0.6608
194		5	5	0.0580	0.0916	0.0198	0.1429	0.6877
195		5	5	0.0800	0.0959	0.0227	0.1214	0.6801
196	70	1	5	0.1154	0.0812	0.0275	0.2722	0.5037
197	70	1	5	0.1992	0.0857	0.0307	0.1978	0.4865
198	70	1	5	0.2427	0.0350	0.0277	0.1956	0.4989
199	70	1	5	0.2929	0.0320	0.0290	0.2097	0.4364

200		1	1	0.3508	0.0419	0.0194	0.2458	0.3420
201	70	1	5	0.3446	0.0307	0.0187	0.2481	0.3580
202		1	1	0.3887	0.0243	0.0182	0.2433	0.3257
203		1	1	0.4685	0.0195	0.0178	0.1613	0.3329
204		1	1	0.5464	0.0188	0.0200	0.1759	0.2389
205		1	1	0.5701	0.0182	0.0153	0.1679	0.2285
206	70	1	4	0.3368	0.0495	0.0242	0.5373	0.0523
207	25	1	4	0.3893	0.0175	0.0189	0.5124	0.0620
208		1	1	0.4866	0.0139	0.0179	0.4119	0.0697
209		1	1	0.7065	0.0155	0.0170	0.1949	0.0660
210		1	1	0.7393	0.0115	0.0148	0.1811	0.0534
211		1	1	0.8046	0.0024	0.0123	0.1465	0.0343
212		1	1	0.6181	0.0017	0.0044	0.3200	0.0559
213		1	1	0.6455	0.0011	0.0038	0.2978	0.0519
214		1	1	0.6947	0.0010	0.0033	0.2597	0.0414
215		1	1	0.4979	0.0012	0.0034	0.4282	0.0693
216		1	1	0.5630	0.0010	0.0031	0.3672	0.0657
217		1	1	0.6816	0.0010	0.0030	0.2495	0.0650
218		1	1	0.6521	0.0023	0.0051	0.1140	0.2265
219		1	1	0.7667	0.0010	0.0034	0.0957	0.1333
220		1	1	0.7873	0.0010	0.0031	0.1286	0.0800
221		1	1	0.6186	0.0014	0.0040	0.2384	0.1375
222		1	1	0.6819	0.0010	0.0031	0.1941	0.1200
223		1	1	0.5556	0.0011	0.0045	0.2295	0.2093
224		1	1	0.6387	0.0010	0.0034	0.2253	0.1316
225		1	1	0.5929	0.0010	0.0028	0.2689	0.1344
226		1	1	0.5644	0.0010	0.0027	0.1967	0.2352
227		1	1	0.5870	0.0010	0.0022	0.1833	0.2265
228		1	1	0.7322	0.0010	0.0014	0.1921	0.0733
229		1	1	0.7451	0.0010	0.0013	0.1724	0.0802
230		1	1	0.7427	0.0013	0.0013	0.2213	0.0335
231		1	1	0.7616	0.0010	0.0013	0.2056	0.0305
232		1	1	0.7895	0.0010	0.0010	0.1813	0.0272
233		1	1	0.8916	0.0010	0.0010	0.0865	0.0198
234		1	1	0.9085	0.0010	0.0010	0.0734	0.0161
235		1	1	0.9045	0.0012	0.0010	0.0730	0.0204
236		1	1	0.9203	0.0010	0.0010	0.0581	0.0196
237		1	1	0.9166	0.0010	0.0010	0.0610	0.0203
238		1	1	0.9120	0.0010	0.0012	0.0660	0.0199
239		1	1	0.8499	0.0015	0.0033	0.1071	0.0383
240		1	1	0.9232	0.0010	0.0025	0.0511	0.0222

E.7 KREST Results from Trajectory Seven Residuals.

KREST: Kalman filter Expert SysTem.
NFRMS: 240
ITraj: 7

#	Rule	KR	MAP	P1	P2	P3	P4	P5
1		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
2		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
3		1	1	0.9602	0.0097	0.0099	0.0098	0.0103
4		1	1	0.9546	0.0068	0.0092	0.0068	0.0226
5		1	1	0.9762	0.0014	0.0113	0.0010	0.0101
6		1	1	0.9765	0.0010	0.0111	0.0010	0.0104
7		1	1	0.9742	0.0010	0.0103	0.0012	0.0134
8		1	1	0.9744	0.0010	0.0101	0.0011	0.0135
9		1	1	0.9677	0.0010	0.0103	0.0011	0.0199
10		1	1	0.9646	0.0010	0.0080	0.0010	0.0254
11		1	1	0.9644	0.0010	0.0079	0.0010	0.0257
12		1	1	0.9614	0.0010	0.0073	0.0012	0.0291
13		1	1	0.9566	0.0012	0.0066	0.0013	0.0343
14		1	1	0.9731	0.0010	0.0073	0.0013	0.0173
15		1	1	0.9602	0.0025	0.0111	0.0019	0.0244
16		1	1	0.9371	0.0081	0.0208	0.0074	0.0266
17		1	1	0.6666	0.0974	0.0956	0.0963	0.0441
18		1	1	0.7800	0.0197	0.1138	0.0158	0.0707
19		3	3	0.2955	0.0668	0.4880	0.1305	0.0192
20		1	1	0.6512	0.0199	0.2002	0.0699	0.0588
21		1	1	0.5027	0.0205	0.3637	0.0765	0.0366
22		3	3	0.2686	0.0457	0.5750	0.0766	0.0341
23		3	3	0.2218	0.0486	0.6124	0.0789	0.0383
24		3	3	0.2802	0.0378	0.5747	0.0775	0.0298
25	40	1	3	0.3437	0.0222	0.5254	0.0770	0.0318
26		3	3	0.0633	0.0395	0.7546	0.1335	0.0091
27		3	3	0.1548	0.0163	0.7160	0.0954	0.0176
28	40	1	3	0.3365	0.0120	0.5416	0.0602	0.0496
29	40	1	3	0.3920	0.0058	0.4872	0.0579	0.0571
30		3	3	0.3294	0.0016	0.5696	0.0398	0.0596
31	40	1	3	0.3705	0.0018	0.4979	0.0381	0.0917
32	40	1	3	0.3723	0.0014	0.4516	0.0264	0.1483
33		3	3	0.3624	0.0010	0.4979	0.0177	0.1209
34	40	1	3	0.3783	0.0010	0.4809	0.0141	0.1256
35		3	3	0.2456	0.0048	0.6813	0.0082	0.0601

36	40	1	3	0.4119	0.0010	0.5149	0.0010	0.0712
37		3	3	0.3481	0.0033	0.4622	0.0014	0.1850
38	40	1	3	0.3697	0.0031	0.4835	0.0010	0.1427
39	40	1	3	0.3813	0.0015	0.4750	0.0010	0.1412
40		1	1	0.4706	0.0010	0.3663	0.0010	0.1610
41		1	1	0.5118	0.0010	0.2685	0.0010	0.2178
42		1	1	0.5231	0.0010	0.2657	0.0010	0.2092
43		1	1	0.5790	0.0010	0.1673	0.0010	0.2517
44		1	1	0.6508	0.0010	0.1443	0.0010	0.2029
45		1	1	0.5988	0.0010	0.2331	0.0010	0.1662
46		1	1	0.6655	0.0010	0.1837	0.0010	0.1488
47		1	1	0.5952	0.0016	0.2332	0.0010	0.1690
48		1	1	0.6321	0.0010	0.2000	0.0011	0.1657
49		1	1	0.5208	0.0011	0.2691	0.0010	0.2080
50		3	3	0.4007	0.0021	0.4202	0.0021	0.1750
51		3	3	0.3689	0.0018	0.4580	0.0010	0.1703
52		1	1	0.4912	0.0010	0.2799	0.0010	0.2269
53		1	1	0.6037	0.0010	0.1228	0.0010	0.2715
54		1	1	0.5810	0.0011	0.1324	0.0010	0.2844
55	70	1	5	0.3839	0.0010	0.1149	0.0010	0.4992
56	70	1	5	0.2542	0.0010	0.1618	0.0010	0.5820
57	70	1	5	0.2671	0.0010	0.1309	0.0011	0.5999
58	70	1	5	0.2665	0.0010	0.1517	0.0010	0.5797
59		5	5	0.2718	0.0010	0.0743	0.0010	0.6519
60	70	1	5	0.2991	0.0010	0.1072	0.0010	0.5917
61	25	1	5	0.3240	0.0011	0.0725	0.0010	0.6014
62		5	5	0.2312	0.0010	0.0360	0.0010	0.7308
63		5	5	0.0497	0.0078	0.0689	0.0031	0.8706
64		3	3	0.0010	0.1181	0.8263	0.0320	0.0226
65		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
66		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
67		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
68		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
69		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
70		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
71		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
72		2	2	0.0230	0.9698	0.0010	0.0045	0.0018
73		2	2	0.0061	0.9900	0.0010	0.0010	0.0020
74		2	2	0.0333	0.9590	0.0010	0.0023	0.0044
75		2	2	0.0988	0.8837	0.0010	0.0022	0.0142
76		2	2	0.1089	0.8727	0.0010	0.0033	0.0141

77	2	2	0.2318	0.7392	0.0010	0.0048	0.0233
78	2	2	0.2733	0.7024	0.0010	0.0027	0.0206
79	2	2	0.4346	0.5243	0.0010	0.0052	0.0349
80	1	1	0.6093	0.3410	0.0010	0.0064	0.0424
81	1	1	0.7233	0.2139	0.0010	0.0090	0.0529
82	1	1	0.8653	0.0555	0.0010	0.0075	0.0707
83	1	1	0.8663	0.0175	0.0017	0.0054	0.1092
84	1	1	0.8382	0.0022	0.0010	0.0038	0.1549
85	1	1	0.8708	0.0012	0.0010	0.0049	0.1220
86	1	1	0.7662	0.0010	0.0010	0.0010	0.2308
87	1	1	0.7894	0.0010	0.0010	0.0010	0.2076
88	1	1	0.7156	0.0010	0.0010	0.0010	0.2814
89	1	1	0.6715	0.0015	0.0010	0.0012	0.3248
90	1	1	0.7441	0.0017	0.0010	0.0014	0.2517
91	1	1	0.7037	0.0026	0.0010	0.0043	0.2884
92	1	1	0.7309	0.0030	0.0010	0.0035	0.2616
93	1	1	0.6778	0.0099	0.0011	0.0155	0.2957
94	1	1	0.7595	0.0010	0.0010	0.0010	0.2375
95	1	1	0.7776	0.0010	0.0010	0.0010	0.2194
96	1	1	0.7790	0.0198	0.0010	0.0267	0.1736
97	1	1	0.5160	0.1012	0.0016	0.1656	0.2156
98	1	1	0.3588	0.1812	0.0024	0.1574	0.3002
99	2	2	0.0699	0.4300	0.0012	0.3151	0.1837
100	2	2	0.0071	0.7272	0.0010	0.2428	0.0218
101	2	2	0.0010	0.9342	0.0010	0.0499	0.0139
102	2	2	0.0010	0.9923	0.0010	0.0026	0.0031
103	2	2	0.0312	0.7040	0.0194	0.0015	0.2440
104	2	2	0.0015	0.4948	0.0184	0.0010	0.4843
105	2	2	0.0010	0.8041	0.0190	0.0010	0.1749
106	2	2	0.0010	0.9793	0.0050	0.0010	0.0138
107	2	2	0.0010	0.9936	0.0028	0.0010	0.0016
108	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
109	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
110	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
111	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
112	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
113	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
114	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
115	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
116	2	2	0.0010	0.9959	0.0011	0.0010	0.0010
117	2	2	0.0010	0.9960	0.0010	0.0010	0.0010

118	2	2	0.0028	0.9813	0.0057	0.0012	0.0090
119	2	2	0.0010	0.9867	0.0066	0.0010	0.0047
120	2	2	0.0010	0.9864	0.0095	0.0012	0.0019
121	2	2	0.0010	0.9912	0.0056	0.0010	0.0012
122	2	2	0.0010	0.9947	0.0023	0.0010	0.0010
123	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
124	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
125	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
126	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
127	2	2	0.0010	0.9955	0.0013	0.0012	0.0010
128	2	2	0.0055	0.9592	0.0184	0.0015	0.0155
129	2	2	0.0010	0.9931	0.0033	0.0016	0.0010
130	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
131	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
132	2	2	0.0010	0.9956	0.0010	0.0014	0.0010
133	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
134	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
135	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
136	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
137	2	2	0.0013	0.9936	0.0021	0.0017	0.0013
138	2	2	0.0058	0.9884	0.0027	0.0012	0.0020
139	2	2	0.0010	0.9957	0.0010	0.0010	0.0013
140	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
141	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
142	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
143	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
144	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
145	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
146	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
147	2	2	0.0023	0.9934	0.0010	0.0017	0.0015
148	2	2	0.0100	0.9743	0.0010	0.0079	0.0067
149	2	2	0.0100	0.9744	0.0010	0.0075	0.0071
150	2	2	0.0145	0.9677	0.0014	0.0072	0.0091
151	2	2	0.0246	0.9468	0.0010	0.0112	0.0163
152	2	2	0.0322	0.9280	0.0010	0.0180	0.0208
153	2	2	0.0357	0.9245	0.0010	0.0190	0.0198
154	2	2	0.0477	0.9081	0.0021	0.0233	0.0188
155	2	2	0.0586	0.8947	0.0010	0.0296	0.0161
156	2	2	0.0834	0.8571	0.0015	0.0372	0.0209
157	2	2	0.0934	0.8471	0.0015	0.0342	0.0237
158	2	2	0.0948	0.8507	0.0017	0.0290	0.0239

159	2	2	0.1349	0.7948	0.0015	0.0477	0.0211
160	2	2	0.1190	0.8313	0.0010	0.0335	0.0151
161	2	2	0.0852	0.8717	0.0010	0.0273	0.0148
162	2	2	0.0487	0.9231	0.0010	0.0186	0.0086
163	2	2	0.0594	0.9113	0.0010	0.0203	0.0080
164	2	2	0.2221	0.7209	0.0019	0.0345	0.0205
165	2	2	0.2254	0.7173	0.0017	0.0417	0.0138
166	2	2	0.2756	0.6704	0.0016	0.0343	0.0181
167	2	2	0.2379	0.6948	0.0019	0.0397	0.0257
168	2	2	0.1922	0.7538	0.0020	0.0163	0.0357
169	2	2	0.1825	0.7564	0.0021	0.0172	0.0419
170	2	2	0.1840	0.7568	0.0023	0.0155	0.0414
171	2	2	0.0191	0.9249	0.0011	0.0132	0.0418
172	2	2	0.1184	0.6112	0.0034	0.0278	0.2393
173	2	2	0.2278	0.4931	0.0040	0.0431	0.2319
174	2	2	0.2966	0.4366	0.0035	0.0374	0.2259
175	2	2	0.3397	0.4029	0.0038	0.0435	0.2101
176	1	1	0.4184	0.3313	0.0057	0.0629	0.1817
177	2	2	0.3053	0.4281	0.0059	0.0974	0.1633
178	2	2	0.3087	0.3969	0.0085	0.1472	0.1387
179	1	1	0.3874	0.2561	0.0122	0.1862	0.1581
180	1	1	0.3443	0.2287	0.0083	0.0775	0.3412
181	1	1	0.3831	0.1791	0.0097	0.0941	0.3340
182	1	1	0.4693	0.0848	0.0083	0.0848	0.3528
183	1	1	0.5193	0.0746	0.0074	0.0691	0.3297
184	1	1	0.5722	0.0576	0.0067	0.0627	0.3007
185	1	1	0.4382	0.1031	0.0064	0.0556	0.3966
186	1	1	0.4019	0.3028	0.0058	0.1267	0.1629
187	1	1	0.5008	0.2339	0.0051	0.1086	0.1516
188	1	1	0.6056	0.1083	0.0058	0.1034	0.1720
189	1	1	0.5034	0.1444	0.0085	0.2705	0.0732
190	1	1	0.6207	0.0886	0.0069	0.2082	0.0756
191	1	1	0.6095	0.1128	0.0052	0.1233	0.1492
192	1	1	0.5138	0.1516	0.0060	0.0694	0.2592
193	1	1	0.4319	0.1915	0.0068	0.1073	0.2624
194	1	1	0.4813	0.1599	0.0059	0.1125	0.2404
195	1	1	0.5681	0.1297	0.0049	0.0901	0.2072
196	1	1	0.5469	0.2071	0.0069	0.1610	0.0781
197	1	1	0.6787	0.1277	0.0056	0.1016	0.0864
198	1	1	0.7725	0.0662	0.0039	0.0746	0.0828
199	1	1	0.8019	0.0509	0.0035	0.0681	0.0756

200	1	1	0.7240	0.0418	0.0017	0.0817	0.1508
201	1	1	0.7803	0.0234	0.0018	0.0768	0.1177
202	1	1	0.8264	0.0145	0.0015	0.0592	0.0984
203	1	1	0.8533	0.0098	0.0013	0.0456	0.0901
204	1	1	0.8699	0.0095	0.0012	0.0534	0.0660
205	1	1	0.8608	0.0088	0.0010	0.0624	0.0670
206	1	1	0.8812	0.0073	0.0010	0.0594	0.0510
207	1	1	0.9027	0.0059	0.0010	0.0455	0.0449
208	1	1	0.9174	0.0043	0.0010	0.0394	0.0380
209	1	1	0.9135	0.0032	0.0010	0.0213	0.0609
210	1	1	0.9303	0.0016	0.0010	0.0147	0.0524
211	1	1	0.9466	0.0013	0.0010	0.0131	0.0381
212	1	1	0.9442	0.0010	0.0010	0.0134	0.0404
213	1	1	0.9541	0.0010	0.0010	0.0097	0.0342
214	1	1	0.9575	0.0010	0.0010	0.0081	0.0324
215	1	1	0.9601	0.0010	0.0010	0.0098	0.0282
216	1	1	0.9698	0.0010	0.0010	0.0066	0.0216
217	1	1	0.9769	0.0010	0.0010	0.0054	0.0157
218	1	1	0.9326	0.0022	0.0020	0.0053	0.0579
219	1	1	0.9757	0.0010	0.0011	0.0050	0.0171
220	1	1	0.9836	0.0010	0.0010	0.0042	0.0102
221	1	1	0.9860	0.0010	0.0010	0.0021	0.0099
222	1	1	0.9866	0.0010	0.0010	0.0016	0.0098
223	1	1	0.9794	0.0018	0.0011	0.0020	0.0158
224	1	1	0.9873	0.0010	0.0010	0.0015	0.0092
225	1	1	0.9891	0.0010	0.0010	0.0011	0.0078
226	1	1	0.9833	0.0010	0.0010	0.0010	0.0137
227	1	1	0.9852	0.0010	0.0010	0.0010	0.0118
228	1	1	0.9915	0.0010	0.0010	0.0010	0.0055
229	1	1	0.9935	0.0010	0.0010	0.0010	0.0035
230	1	1	0.9850	0.0102	0.0010	0.0021	0.0018
231	1	1	0.9868	0.0086	0.0010	0.0018	0.0017
232	1	1	0.9920	0.0041	0.0010	0.0014	0.0015
233	1	1	0.9952	0.0016	0.0010	0.0010	0.0012
234	1	1	0.9959	0.0011	0.0010	0.0010	0.0010
235	1	1	0.9960	0.0010	0.0010	0.0010	0.0010
236	1	1	0.9960	0.0010	0.0010	0.0010	0.0010
237	1	1	0.9951	0.0010	0.0013	0.0010	0.0016
238	1	1	0.9956	0.0010	0.0012	0.0010	0.0012
239	1	1	0.9957	0.0010	0.0013	0.0010	0.0010
240	1	1	0.9960	0.0010	0.0010	0.0010	0.0010

E.8 KREST Results from Trajectory Eight Residuals.

KREST: Kalman filter Expert SysTem.
NFRMS: 240
ITraj: 8

#	Rule	KR	MAP	P1	P2	P3	P4	P5
1		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
2		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
3		1	1	0.9602	0.0097	0.0099	0.0098	0.0103
4		1	1	0.9546	0.0068	0.0092	0.0068	0.0226
5		1	1	0.9762	0.0014	0.0113	0.0010	0.0101
6		1	1	0.9765	0.0010	0.0111	0.0010	0.0104
7		1	1	0.9742	0.0010	0.0103	0.0012	0.0134
8		1	1	0.9744	0.0010	0.0101	0.0011	0.0135
9		1	1	0.9677	0.0010	0.0103	0.0011	0.0199
10		1	1	0.9646	0.0010	0.0080	0.0010	0.0254
11		1	1	0.9644	0.0010	0.0079	0.0010	0.0257
12		1	1	0.9614	0.0010	0.0073	0.0012	0.0291
13		1	1	0.9566	0.0012	0.0066	0.0013	0.0343
14		1	1	0.9731	0.0010	0.0073	0.0013	0.0173
15		1	1	0.9602	0.0025	0.0111	0.0019	0.0244
16		1	1	0.9371	0.0081	0.0208	0.0074	0.0266
17		1	1	0.6666	0.0974	0.0956	0.0963	0.0441
18		1	1	0.7800	0.0197	0.1138	0.0158	0.0707
19		3	3	0.2955	0.0668	0.4880	0.1305	0.0192
20		1	1	0.6512	0.0199	0.2002	0.0699	0.0588
21		1	1	0.5027	0.0205	0.3637	0.0765	0.0366
22		3	3	0.2686	0.0457	0.5750	0.0766	0.0341
23		3	3	0.2218	0.0486	0.6124	0.0789	0.0383
24		3	3	0.2802	0.0378	0.5747	0.0775	0.0298
25	40	1	3	0.3437	0.0222	0.5254	0.0770	0.0318
26		3	3	0.0633	0.0395	0.7546	0.1335	0.0091
27		3	3	0.1548	0.0163	0.7160	0.0954	0.0176
28	40	1	3	0.3365	0.0120	0.5416	0.0602	0.0496
29	40	1	3	0.3920	0.0058	0.4872	0.0579	0.0571
30		3	3	0.3294	0.0016	0.5696	0.0398	0.0596
31	40	1	3	0.3705	0.0018	0.4979	0.0381	0.0917
32	40	1	3	0.3723	0.0014	0.4516	0.0264	0.1483
33		3	3	0.3624	0.0010	0.4979	0.0177	0.1209
34	40	1	3	0.3783	0.0010	0.4809	0.0141	0.1256
35		3	3	0.2456	0.0048	0.6813	0.0082	0.0601

36	40	1	3	0.4119	0.0010	0.5149	0.0010	0.0712
37		3	3	0.3481	0.0033	0.4622	0.0014	0.1850
38	40	1	3	0.3697	0.0031	0.4835	0.0010	0.1427
39	40	1	3	0.3813	0.0015	0.4750	0.0010	0.1412
40		1	1	0.4706	0.0010	0.3663	0.0010	0.1610
41		1	1	0.5118	0.0010	0.2685	0.0010	0.2178
42		1	1	0.5231	0.0010	0.2657	0.0010	0.2092
43		1	1	0.5790	0.0010	0.1673	0.0010	0.2517
44		1	1	0.6508	0.0010	0.1443	0.0010	0.2029
45		1	1	0.5988	0.0010	0.2331	0.0010	0.1662
46		1	1	0.6655	0.0010	0.1837	0.0010	0.1488
47		1	1	0.5952	0.0016	0.2332	0.0010	0.1690
48		1	1	0.6321	0.0010	0.2000	0.0011	0.1657
49		1	1	0.5208	0.0011	0.2691	0.0010	0.2080
50		3	3	0.4007	0.0021	0.4202	0.0021	0.1750
51		3	3	0.3689	0.0018	0.4580	0.0010	0.1703
52		1	1	0.4912	0.0010	0.2799	0.0010	0.2269
53		1	1	0.6037	0.0010	0.1228	0.0010	0.2715
54		1	1	0.5810	0.0011	0.1324	0.0010	0.2844
55	70	1	5	0.3839	0.0010	0.1149	0.0010	0.4992
56	70	1	5	0.2542	0.0010	0.1618	0.0010	0.5820
57	70	1	5	0.2671	0.0010	0.1309	0.0011	0.5999
58	70	1	5	0.2665	0.0010	0.1517	0.0010	0.5797
59		5	5	0.2718	0.0010	0.0743	0.0010	0.6519
60	70	1	5	0.2991	0.0010	0.1072	0.0010	0.5917
61	25	1	5	0.3240	0.0011	0.0725	0.0010	0.6014
62		5	5	0.2312	0.0010	0.0360	0.0010	0.7308
63		5	5	0.0497	0.0078	0.0689	0.0031	0.8706
64		3	3	0.0010	0.1181	0.8263	0.0320	0.0226
65		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
66		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
67		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
68		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
69		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
70		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
71		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
72		2	2	0.0230	0.9698	0.0010	0.0045	0.0018
73		2	2	0.0061	0.9900	0.0010	0.0010	0.0020
74		2	2	0.0333	0.9590	0.0010	0.0023	0.0044
75		2	2	0.0988	0.8837	0.0010	0.0022	0.0142
76		2	2	0.1089	0.8727	0.0010	0.0033	0.0141

77	2	2	0.2318	0.7392	0.0010	0.0048	0.0233
78	2	2	0.2733	0.7024	0.0010	0.0027	0.0206
79	2	2	0.4346	0.5243	0.0010	0.0052	0.0349
80	1	1	0.6093	0.3410	0.0010	0.0064	0.0424
81	1	1	0.7233	0.2139	0.0010	0.0090	0.0529
82	1	1	0.8653	0.0555	0.0010	0.0075	0.0707
83	1	1	0.8663	0.0175	0.0017	0.0054	0.1092
84	1	1	0.8382	0.0022	0.0010	0.0038	0.1549
85	1	1	0.8708	0.0012	0.0010	0.0049	0.1220
86	1	1	0.7662	0.0010	0.0010	0.0010	0.2308
87	1	1	0.7894	0.0010	0.0010	0.0010	0.2076
88	1	1	0.7156	0.0010	0.0010	0.0010	0.2814
89	1	1	0.6715	0.0015	0.0010	0.0012	0.3248
90	1	1	0.7441	0.0017	0.0010	0.0014	0.2517
91	1	1	0.7037	0.0026	0.0010	0.0043	0.2884
92	1	1	0.7309	0.0030	0.0010	0.0035	0.2616
93	1	1	0.6778	0.0099	0.0011	0.0155	0.2957
94	1	1	0.7595	0.0010	0.0010	0.0010	0.2375
95	1	1	0.7776	0.0010	0.0010	0.0010	0.2194
96	1	1	0.7790	0.0198	0.0010	0.0267	0.1736
97	1	1	0.5160	0.1012	0.0016	0.1656	0.2156
98	1	1	0.3588	0.1812	0.0024	0.1574	0.3002
99	2	2	0.0699	0.4300	0.0012	0.3151	0.1837
100	2	2	0.0071	0.7272	0.0010	0.2428	0.0218
101	2	2	0.0010	0.9342	0.0010	0.0499	0.0139
102	2	2	0.0010	0.9923	0.0010	0.0026	0.0031
103	2	2	0.0312	0.7040	0.0194	0.0015	0.2440
104	2	2	0.0015	0.4948	0.0184	0.0010	0.4843
105	2	2	0.0010	0.8041	0.0190	0.0010	0.1749
106	2	2	0.0010	0.9793	0.0050	0.0010	0.0138
107	2	2	0.0010	0.9936	0.0028	0.0010	0.0016
108	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
109	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
110	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
111	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
112	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
113	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
114	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
115	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
116	2	2	0.0010	0.9959	0.0011	0.0010	0.0010
117	2	2	0.0010	0.9960	0.0010	0.0010	0.0010

118	2	2	0.0028	0.9813	0.0057	0.0012	0.0090
119	2	2	0.0010	0.9867	0.0066	0.0010	0.0047
120	2	2	0.0010	0.9864	0.0095	0.0012	0.0019
121	2	2	0.0010	0.9912	0.0056	0.0010	0.0012
122	2	2	0.0010	0.9947	0.0023	0.0010	0.0010
123	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
124	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
125	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
126	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
127	2	2	0.0010	0.9955	0.0013	0.0012	0.0010
128	2	2	0.0055	0.9592	0.0184	0.0015	0.0155
129	2	2	0.0010	0.9931	0.0033	0.0016	0.0010
130	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
131	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
132	2	2	0.0010	0.9956	0.0010	0.0014	0.0010
133	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
134	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
135	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
136	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
137	2	2	0.0016	0.9929	0.0023	0.0016	0.0016
138	2	2	0.0034	0.9911	0.0020	0.0012	0.0023
139	2	2	0.0010	0.9896	0.0010	0.0013	0.0071
140	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
141	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
142	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
143	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
144	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
145	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
146	2	2	0.0057	0.9908	0.0010	0.0016	0.0010
147	2	2	0.0081	0.9878	0.0010	0.0021	0.0010
148	2	2	0.0300	0.9601	0.0010	0.0044	0.0045
149	2	2	0.0263	0.9639	0.0010	0.0043	0.0044
150	2	2	0.0321	0.9575	0.0010	0.0045	0.0049
151	2	2	0.0641	0.9174	0.0010	0.0080	0.0095
152	2	2	0.0419	0.9441	0.0010	0.0056	0.0074
153	2	2	0.0466	0.9391	0.0010	0.0058	0.0074
154	2	2	0.0315	0.9586	0.0012	0.0031	0.0055
155	2	2	0.0264	0.9672	0.0010	0.0024	0.0030
156	2	2	0.0378	0.9534	0.0014	0.0038	0.0036
157	2	2	0.0402	0.9507	0.0015	0.0034	0.0042
158	2	2	0.0355	0.9562	0.0014	0.0035	0.0034

159	2	2	0.0547	0.9349	0.0015	0.0057	0.0032
160	2	2	0.0374	0.9560	0.0010	0.0035	0.0021
161	2	2	0.0461	0.9463	0.0011	0.0036	0.0029
162	2	2	0.0089	0.9858	0.0010	0.0029	0.0014
163	2	2	0.0119	0.9823	0.0010	0.0032	0.0015
164	2	2	0.0479	0.9395	0.0024	0.0069	0.0033
165	2	2	0.0682	0.9130	0.0028	0.0120	0.0040
166	2	2	0.0736	0.9027	0.0037	0.0142	0.0058
167	2	2	0.0719	0.9078	0.0035	0.0119	0.0048
168	2	2	0.1368	0.8346	0.0072	0.0124	0.0090
169	2	2	0.1548	0.8141	0.0083	0.0124	0.0105
170	2	2	0.1765	0.7892	0.0099	0.0142	0.0101
171	2	2	0.0124	0.9698	0.0024	0.0121	0.0033
172	2	2	0.1024	0.8327	0.0075	0.0367	0.0208
173	2	2	0.2235	0.6801	0.0097	0.0629	0.0238
174	2	2	0.2824	0.6124	0.0073	0.0730	0.0249
175	2	2	0.3446	0.5425	0.0074	0.0813	0.0243
176	1	1	0.5298	0.3454	0.0123	0.0849	0.0277
177	1	1	0.4691	0.3796	0.0133	0.1141	0.0239
178	2	2	0.4039	0.4233	0.0151	0.1426	0.0151
179	1	1	0.5305	0.2796	0.0197	0.1522	0.0180
180	1	1	0.4724	0.3730	0.0087	0.0975	0.0484
181	1	1	0.4955	0.3198	0.0087	0.1229	0.0530
182	1	1	0.6438	0.1943	0.0063	0.0977	0.0579
183	1	1	0.6724	0.1574	0.0051	0.0990	0.0661
184	1	1	0.7321	0.1228	0.0045	0.0857	0.0550
185	1	1	0.6517	0.1911	0.0053	0.0994	0.0524
186	1	1	0.5100	0.3522	0.0043	0.1086	0.0248
187	1	1	0.6030	0.2640	0.0043	0.1043	0.0244
188	1	1	0.6391	0.1760	0.0060	0.1491	0.0298
189	1	1	0.4717	0.2072	0.0082	0.3052	0.0077
190	1	1	0.6201	0.1293	0.0076	0.2355	0.0074
191	1	1	0.6548	0.1284	0.0057	0.1992	0.0119
192	1	1	0.6109	0.2255	0.0082	0.1356	0.0198
193	1	1	0.3943	0.3575	0.0093	0.2295	0.0094
194	1	1	0.4275	0.3023	0.0088	0.2530	0.0084
195	1	1	0.5606	0.2284	0.0066	0.1977	0.0068
196	1	1	0.3855	0.3148	0.0083	0.2888	0.0026
197	1	1	0.5163	0.3216	0.0090	0.1482	0.0050
198	1	1	0.6494	0.2118	0.0073	0.1258	0.0056
199	1	1	0.7000	0.1758	0.0071	0.1116	0.0055

200	1	1	0.7916	0.1137	0.0055	0.0810	0.0081
201	1	1	0.8541	0.0491	0.0044	0.0881	0.0043
202	1	1	0.8882	0.0275	0.0040	0.0768	0.0036
203	1	1	0.9314	0.0199	0.0034	0.0417	0.0036
204	1	1	0.9387	0.0168	0.0032	0.0382	0.0031
205	1	1	0.9466	0.0124	0.0026	0.0356	0.0027
206	1	1	0.9577	0.0116	0.0022	0.0258	0.0028
207	1	1	0.9646	0.0110	0.0020	0.0198	0.0028
208	1	1	0.9710	0.0080	0.0016	0.0169	0.0025
209	1	1	0.9709	0.0068	0.0020	0.0177	0.0026
210	1	1	0.9786	0.0033	0.0016	0.0145	0.0019
211	1	1	0.9848	0.0023	0.0012	0.0103	0.0015
212	1	1	0.9827	0.0014	0.0011	0.0137	0.0011
213	1	1	0.9857	0.0010	0.0010	0.0113	0.0010
214	1	1	0.9892	0.0010	0.0010	0.0078	0.0010
215	1	1	0.9876	0.0010	0.0010	0.0094	0.0010
216	1	1	0.9908	0.0010	0.0010	0.0062	0.0010
217	1	1	0.9920	0.0010	0.0010	0.0050	0.0010
218	1	1	0.9889	0.0017	0.0020	0.0049	0.0025
219	1	1	0.9926	0.0010	0.0011	0.0043	0.0010
220	1	1	0.9948	0.0010	0.0010	0.0022	0.0010
221	1	1	0.9925	0.0010	0.0010	0.0045	0.0010
222	1	1	0.9936	0.0010	0.0010	0.0034	0.0010
223	1	1	0.9931	0.0013	0.0013	0.0032	0.0012
224	1	1	0.9951	0.0010	0.0010	0.0019	0.0010
225	1	1	0.9950	0.0010	0.0010	0.0020	0.0010
226	1	1	0.9937	0.0010	0.0011	0.0020	0.0021
227	1	1	0.9945	0.0010	0.0010	0.0016	0.0019
228	1	1	0.9959	0.0010	0.0010	0.0011	0.0010
229	1	1	0.9960	0.0010	0.0010	0.0011	0.0010
230	1	1	0.9884	0.0073	0.0018	0.0015	0.0010
231	1	1	0.9900	0.0056	0.0021	0.0013	0.0010
232	1	1	0.9936	0.0027	0.0016	0.0011	0.0010
233	1	1	0.9960	0.0010	0.0010	0.0010	0.0010
234	1	1	0.9960	0.0010	0.0010	0.0010	0.0010
235	1	1	0.9960	0.0010	0.0010	0.0010	0.0010
236	1	1	0.9960	0.0010	0.0010	0.0010	0.0010
237	1	1	0.9960	0.0010	0.0010	0.0010	0.0010
238	1	1	0.9960	0.0010	0.0010	0.0010	0.0010
239	1	1	0.9952	0.0010	0.0018	0.0010	0.0010
240	1	1	0.9958	0.0010	0.0013	0.0010	0.0010

E.9 KREST Results from Trajectory Nine Residuals.

KREST: Kalman filter Expert SysTem.
NFRMS: 240
ITraj: 9

#	Rule	KR	MAP	P1	P2	P3	P4	P5
1		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
2		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
3		1	1	0.9606	0.0096	0.0098	0.0101	0.0099
4		1	1	0.9654	0.0037	0.0076	0.0113	0.0121
5		1	1	0.9698	0.0034	0.0078	0.0067	0.0123
6		1	1	0.9701	0.0034	0.0074	0.0065	0.0126
7		1	1	0.9661	0.0045	0.0068	0.0091	0.0135
8		1	1	0.9664	0.0041	0.0073	0.0092	0.0131
9		1	1	0.9713	0.0041	0.0079	0.0076	0.0092
10		1	1	0.9785	0.0029	0.0065	0.0047	0.0074
11		1	1	0.9810	0.0020	0.0062	0.0042	0.0066
12		1	1	0.9840	0.0016	0.0057	0.0037	0.0050
13		1	1	0.9814	0.0014	0.0056	0.0051	0.0065
14		1	1	0.9840	0.0010	0.0040	0.0060	0.0050
15		1	1	0.9729	0.0035	0.0065	0.0143	0.0028
16		1	1	0.9443	0.0048	0.0127	0.0349	0.0033
17		1	1	0.8549	0.0104	0.0314	0.1014	0.0019
18		1	1	0.9623	0.0048	0.0144	0.0163	0.0023
19		1	1	0.5690	0.1537	0.0617	0.2109	0.0047
20		1	1	0.8559	0.0454	0.0246	0.0680	0.0061
21		1	1	0.7071	0.0907	0.0463	0.1482	0.0078
22		1	1	0.4801	0.3525	0.0765	0.0855	0.0053
23		1	1	0.5734	0.2678	0.0715	0.0840	0.0033
24		1	1	0.6592	0.1965	0.0615	0.0799	0.0029
25		1	1	0.7312	0.1511	0.0509	0.0644	0.0025
26		1	1	0.4846	0.2183	0.1197	0.1763	0.0010
27		1	1	0.6825	0.1060	0.0843	0.1261	0.0011
28		1	1	0.8209	0.0817	0.0306	0.0657	0.0010
29		1	1	0.8434	0.0717	0.0288	0.0551	0.0010
30		1	1	0.8353	0.0707	0.0358	0.0572	0.0010
31		1	1	0.8919	0.0244	0.0330	0.0497	0.0010
32		1	1	0.9225	0.0120	0.0276	0.0368	0.0010
33		1	1	0.9234	0.0094	0.0289	0.0373	0.0010
34		1	1	0.9379	0.0067	0.0251	0.0294	0.0010
35		1	1	0.8928	0.0044	0.0501	0.0517	0.0010

36		1	1	0.9729	0.0011	0.0172	0.0078	0.0010
37		1	1	0.9616	0.0010	0.0207	0.0157	0.0010
38		1	1	0.9632	0.0010	0.0196	0.0153	0.0010
39		1	1	0.9661	0.0010	0.0182	0.0138	0.0010
40		1	1	0.9756	0.0010	0.0143	0.0081	0.0010
41		1	1	0.9833	0.0010	0.0102	0.0045	0.0010
42		1	1	0.9784	0.0017	0.0118	0.0070	0.0010
43		1	1	0.9845	0.0018	0.0079	0.0048	0.0010
44		1	1	0.9848	0.0010	0.0067	0.0063	0.0012
45		1	1	0.9656	0.0010	0.0190	0.0134	0.0010
46		1	1	0.9743	0.0010	0.0133	0.0105	0.0010
47		1	1	0.9723	0.0016	0.0160	0.0083	0.0019
48		1	1	0.9788	0.0010	0.0111	0.0077	0.0014
49		1	1	0.9718	0.0010	0.0156	0.0096	0.0020
50		1	1	0.9143	0.0026	0.0409	0.0399	0.0024
51		1	1	0.9135	0.0015	0.0527	0.0295	0.0028
52		1	1	0.9528	0.0010	0.0279	0.0169	0.0015
53		1	1	0.9802	0.0010	0.0133	0.0045	0.0011
54		1	1	0.9837	0.0010	0.0110	0.0032	0.0010
55		1	1	0.9727	0.0020	0.0203	0.0027	0.0023
56		1	1	0.9576	0.0032	0.0330	0.0023	0.0039
57		1	1	0.9737	0.0011	0.0200	0.0022	0.0029
58		1	1	0.9669	0.0010	0.0259	0.0024	0.0039
59		1	1	0.9764	0.0010	0.0180	0.0016	0.0030
60		1	1	0.9687	0.0011	0.0266	0.0012	0.0024
61		1	1	0.9709	0.0013	0.0232	0.0010	0.0036
62		1	1	0.9809	0.0010	0.0146	0.0010	0.0025
63		1	1	0.9640	0.0054	0.0209	0.0029	0.0067
64		1	1	0.8789	0.0253	0.0618	0.0105	0.0235
65		1	1	0.5513	0.1438	0.2335	0.0484	0.0231
66	55	3	2	0.0025	0.5040	0.4805	0.0067	0.0063
67	55	3	2	0.0010	0.6038	0.3915	0.0026	0.0010
68		2	2	0.0010	0.8350	0.1620	0.0010	0.0010
69		2	2	0.0010	0.9646	0.0324	0.0010	0.0010
70		2	2	0.0010	0.9885	0.0085	0.0010	0.0010
71		2	2	0.0010	0.9954	0.0016	0.0010	0.0010
72		2	2	0.0010	0.9954	0.0016	0.0010	0.0010
73		2	2	0.0010	0.9870	0.0074	0.0010	0.0036
74		2	2	0.0010	0.9937	0.0033	0.0010	0.0010
75		2	2	0.0010	0.9956	0.0014	0.0010	0.0010
76		2	2	0.0010	0.9960	0.0010	0.0010	0.0010

77	2	2	0.0010	0.9958	0.0012	0.0010	0.0010
78	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
79	2	2	0.0010	0.9959	0.0011	0.0010	0.0010
80	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
81	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
82	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
83	2	2	0.0010	0.9952	0.0018	0.0010	0.0010
84	2	2	0.0010	0.9950	0.0020	0.0010	0.0010
85	2	2	0.0010	0.9955	0.0015	0.0010	0.0010
86	2	2	0.0010	0.9933	0.0014	0.0033	0.0010
87	2	2	0.0013	0.9900	0.0044	0.0025	0.0018
88	2	2	0.0010	0.9955	0.0015	0.0010	0.0010
89	2	2	0.0010	0.9952	0.0018	0.0010	0.0010
90	2	2	0.0010	0.9953	0.0017	0.0010	0.0010
91	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
92	2	2	0.0010	0.9959	0.0011	0.0010	0.0010
93	2	2	0.0010	0.9959	0.0011	0.0010	0.0010
94	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
95	2	2	0.0014	0.9953	0.0010	0.0011	0.0011
96	2	2	0.0019	0.9940	0.0016	0.0010	0.0015
97	2	2	0.0016	0.9949	0.0013	0.0010	0.0012
98	2	2	0.0023	0.9937	0.0015	0.0011	0.0014
99	2	2	0.0015	0.9955	0.0010	0.0010	0.0010
100	2	2	0.0016	0.9944	0.0015	0.0015	0.0010
101	2	2	0.0023	0.9931	0.0017	0.0017	0.0012
102	2	2	0.0043	0.9878	0.0032	0.0024	0.0023
103	2	2	0.0044	0.9894	0.0030	0.0023	0.0010
104	2	2	0.0063	0.9882	0.0026	0.0016	0.0013
105	2	2	0.0108	0.9824	0.0029	0.0019	0.0019
106	2	2	0.0407	0.9456	0.0038	0.0048	0.0051
107	2	2	0.0710	0.9121	0.0061	0.0049	0.0060
108	2	2	0.0882	0.8953	0.0054	0.0047	0.0064
109	2	2	0.1310	0.8467	0.0063	0.0073	0.0088
110	2	2	0.0665	0.9204	0.0033	0.0070	0.0029
111	2	2	0.0874	0.8979	0.0037	0.0078	0.0032
112	2	2	0.1937	0.7839	0.0065	0.0106	0.0054
113	2	2	0.1654	0.7963	0.0096	0.0270	0.0017
114	2	2	0.2253	0.7291	0.0124	0.0310	0.0021
115	2	2	0.3441	0.6144	0.0144	0.0246	0.0026
116	2	2	0.0818	0.8732	0.0126	0.0314	0.0010
117	2	2	0.2797	0.5962	0.0408	0.0803	0.0030

118		2	2	0.4106	0.5377	0.0249	0.0242	0.0026
119		1	1	0.5035	0.4396	0.0283	0.0263	0.0023
120		1	1	0.6774	0.2526	0.0326	0.0350	0.0024
121		1	1	0.8537	0.0812	0.0324	0.0305	0.0023
122		1	1	0.8978	0.0474	0.0286	0.0244	0.0017
123		1	1	0.9206	0.0294	0.0251	0.0228	0.0022
124		1	1	0.9344	0.0181	0.0267	0.0184	0.0024
125		1	1	0.9570	0.0052	0.0207	0.0157	0.0013
126		1	1	0.9643	0.0033	0.0174	0.0139	0.0010
127		1	1	0.9810	0.0010	0.0106	0.0064	0.0010
128		1	1	0.9808	0.0010	0.0132	0.0040	0.0010
129		1	1	0.9787	0.0010	0.0155	0.0027	0.0021
130		1	1	0.9829	0.0010	0.0121	0.0023	0.0017
131		1	1	0.9840	0.0010	0.0111	0.0014	0.0025
132		1	1	0.9701	0.0049	0.0147	0.0015	0.0088
133		1	1	0.9817	0.0017	0.0098	0.0014	0.0054
134		1	1	0.9656	0.0024	0.0187	0.0013	0.0120
135		1	1	0.9659	0.0019	0.0192	0.0018	0.0112
136		1	1	0.9521	0.0054	0.0303	0.0047	0.0076
137		1	1	0.9462	0.0100	0.0300	0.0083	0.0055
138		1	1	0.9351	0.0113	0.0379	0.0117	0.0040
139		1	1	0.9568	0.0039	0.0273	0.0087	0.0033
140		1	1	0.9647	0.0028	0.0226	0.0073	0.0027
141		1	1	0.9780	0.0012	0.0145	0.0027	0.0037
142		1	1	0.8987	0.0125	0.0580	0.0087	0.0221
143	61	1	3	0.2585	0.2451	0.3493	0.0042	0.1428
144	55	3	2	0.0099	0.5315	0.3939	0.0011	0.0635
145	55	3	2	0.0010	0.7359	0.2501	0.0010	0.0120
146		2	2	0.0010	0.9145	0.0819	0.0010	0.0016
147		2	2	0.0010	0.9722	0.0248	0.0010	0.0010
148		2	2	0.0010	0.9835	0.0135	0.0010	0.0010
149		2	2	0.0010	0.9870	0.0101	0.0010	0.0010
150		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
151		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
152		2	2	0.0010	0.9957	0.0013	0.0010	0.0010
153		2	2	0.0010	0.9957	0.0013	0.0010	0.0010
154		2	2	0.0010	0.9960	0.0010	0.0010	0.0010
155		2	2	0.0010	0.9956	0.0014	0.0010	0.0010
156		2	2	0.0010	0.9947	0.0023	0.0010	0.0010
157		2	2	0.0010	0.9951	0.0019	0.0010	0.0010
158		2	2	0.0010	0.9954	0.0016	0.0010	0.0010

159	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
160	2	2	0.0010	0.9958	0.0012	0.0010	0.0010
161	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
162	2	2	0.0103	0.9833	0.0010	0.0010	0.0044
163	2	2	0.0037	0.9912	0.0010	0.0010	0.0031
164	2	2	0.0061	0.9856	0.0036	0.0028	0.0019
165	2	2	0.0015	0.9909	0.0037	0.0029	0.0010
166	2	2	0.0010	0.9922	0.0041	0.0017	0.0010
167	2	2	0.0010	0.9917	0.0049	0.0014	0.0010
168	2	2	0.0010	0.9913	0.0054	0.0010	0.0013
169	2	2	0.0010	0.9912	0.0054	0.0010	0.0014
170	2	2	0.0010	0.9927	0.0042	0.0011	0.0010
171	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
172	2	2	0.0019	0.9936	0.0013	0.0021	0.0011
173	2	2	0.0016	0.9950	0.0010	0.0014	0.0010
174	2	2	0.0043	0.9892	0.0016	0.0037	0.0013
175	2	2	0.0027	0.9912	0.0012	0.0040	0.0010
176	2	2	0.0035	0.9829	0.0022	0.0098	0.0015
177	2	2	0.0010	0.9903	0.0010	0.0067	0.0010
178	2	2	0.0010	0.9860	0.0010	0.0110	0.0010
179	2	2	0.0010	0.9843	0.0011	0.0126	0.0010
180	2	2	0.0057	0.9638	0.0026	0.0221	0.0057
181	2	2	0.0038	0.9633	0.0025	0.0257	0.0047
182	2	2	0.0051	0.9663	0.0024	0.0204	0.0058
183	2	2	0.0076	0.9573	0.0022	0.0258	0.0070
184	2	2	0.0081	0.9559	0.0024	0.0287	0.0049
185	2	2	0.0039	0.9670	0.0013	0.0228	0.0050
186	2	2	0.0046	0.9633	0.0011	0.0259	0.0051
187	2	2	0.0051	0.9595	0.0010	0.0275	0.0068
188	2	2	0.0068	0.9574	0.0012	0.0256	0.0089
189	2	2	0.0061	0.9595	0.0013	0.0267	0.0064
190	2	2	0.0104	0.9503	0.0011	0.0301	0.0082
191	2	2	0.0045	0.9667	0.0010	0.0185	0.0093
192	2	2	0.0018	0.9766	0.0010	0.0074	0.0133
193	2	2	0.0016	0.9804	0.0011	0.0051	0.0117
194	2	2	0.0024	0.9785	0.0011	0.0062	0.0118
195	2	2	0.0049	0.9565	0.0022	0.0154	0.0210
196	2	2	0.0093	0.9409	0.0032	0.0255	0.0210
197	2	2	0.0226	0.8851	0.0038	0.0385	0.0500
198	2	2	0.0155	0.9169	0.0019	0.0301	0.0356
199	2	2	0.0187	0.9094	0.0020	0.0310	0.0389

200		2	2	0.0122	0.9032	0.0014	0.0427	0.0406
201		2	2	0.0055	0.9385	0.0012	0.0370	0.0179
202		2	2	0.0052	0.9389	0.0014	0.0429	0.0116
203		2	2	0.0057	0.9299	0.0016	0.0492	0.0136
204		2	2	0.0028	0.9494	0.0011	0.0418	0.0049
205		2	2	0.0014	0.9515	0.0010	0.0431	0.0030
206		2	2	0.0013	0.9476	0.0010	0.0479	0.0022
207		2	2	0.0017	0.9426	0.0011	0.0526	0.0021
208		2	2	0.0016	0.9354	0.0012	0.0599	0.0019
209		2	2	0.0033	0.9165	0.0018	0.0753	0.0031
210		2	2	0.0021	0.9173	0.0016	0.0771	0.0019
211		2	2	0.0021	0.8818	0.0014	0.1128	0.0020
212		2	2	0.0021	0.8697	0.0013	0.1246	0.0023
213		2	2	0.0021	0.8492	0.0010	0.1455	0.0022
214		2	2	0.0026	0.8251	0.0010	0.1694	0.0018
215		2	2	0.0011	0.8794	0.0010	0.1163	0.0022
216		2	2	0.0010	0.8544	0.0010	0.1416	0.0019
217		2	2	0.0022	0.8268	0.0029	0.1648	0.0034
218		2	2	0.0010	0.8389	0.0027	0.1529	0.0045
219	75	2	4	0.0038	0.4528	0.0066	0.5318	0.0049
220	75	2	4	0.0067	0.4391	0.0074	0.5413	0.0055
221		4	4	0.0119	0.2561	0.0097	0.7145	0.0078
222	75	2	4	0.0152	0.3622	0.0126	0.5988	0.0113
223	75	2	4	0.0099	0.4389	0.0125	0.5268	0.0120
224		4	4	0.0127	0.2055	0.0113	0.7575	0.0130
225		4	4	0.0152	0.1703	0.0094	0.7943	0.0108
226		4	4	0.0164	0.1080	0.0080	0.8588	0.0087
227		4	4	0.0208	0.0815	0.0073	0.8804	0.0099
228		4	4	0.0193	0.0308	0.0058	0.9393	0.0048
229		4	4	0.0305	0.0462	0.0094	0.9067	0.0073
230		4	4	0.0088	0.0444	0.0020	0.9389	0.0059
231		4	4	0.0107	0.0332	0.0014	0.9484	0.0063
232		4	4	0.0119	0.0321	0.0014	0.9472	0.0074
233		4	4	0.0198	0.0385	0.0016	0.9264	0.0137
234		4	4	0.0225	0.0381	0.0017	0.9224	0.0153
235		4	4	0.0228	0.0321	0.0016	0.9344	0.0091
236		4	4	0.0250	0.0474	0.0021	0.9125	0.0131
237		4	4	0.0215	0.0406	0.0020	0.9240	0.0120
238		4	4	0.0132	0.0310	0.0020	0.9489	0.0050
239		4	4	0.0075	0.0393	0.0010	0.9512	0.0010
240		4	4	0.0087	0.0170	0.0010	0.9723	0.0010

E.10 KREST Results from Trajectory Ten Residuals.

KREST: Kalman filter Expert SysTem.
NFRMS: 240
ITraj: 10

#	Rule	KR	MAP	P1	P2	P3	P4	P5
1		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
2		1	1	0.9600	0.0100	0.0100	0.0100	0.0100
3		1	1	0.9606	0.0096	0.0098	0.0101	0.0099
4		1	1	0.9654	0.0037	0.0076	0.0113	0.0121
5		1	1	0.9698	0.0034	0.0078	0.0067	0.0123
6		1	1	0.9701	0.0034	0.0074	0.0065	0.0126
7		1	1	0.9661	0.0045	0.0068	0.0091	0.0135
8		1	1	0.9664	0.0041	0.0073	0.0092	0.0131
9		1	1	0.9713	0.0041	0.0079	0.0076	0.0092
10		1	1	0.9785	0.0029	0.0065	0.0047	0.0074
11		1	1	0.9810	0.0020	0.0062	0.0042	0.0066
12		1	1	0.9840	0.0016	0.0057	0.0037	0.0050
13		1	1	0.9814	0.0014	0.0056	0.0051	0.0065
14		1	1	0.9840	0.0010	0.0040	0.0060	0.0050
15		1	1	0.9729	0.0035	0.0065	0.0143	0.0028
16		1	1	0.9443	0.0048	0.0127	0.0349	0.0033
17		1	1	0.8549	0.0104	0.0314	0.1014	0.0019
18		1	1	0.9623	0.0048	0.0144	0.0163	0.0023
19		1	1	0.5690	0.1537	0.0617	0.2109	0.0047
20		1	1	0.8559	0.0454	0.0246	0.0680	0.0061
21		1	1	0.7071	0.0907	0.0463	0.1482	0.0078
22		1	1	0.4801	0.3525	0.0765	0.0855	0.0053
23		1	1	0.5734	0.2678	0.0715	0.0840	0.0033
24		1	1	0.6592	0.1965	0.0615	0.0799	0.0029
25		1	1	0.7312	0.1511	0.0509	0.0644	0.0025
26		1	1	0.4846	0.2183	0.1197	0.1763	0.0010
27		1	1	0.6825	0.1060	0.0843	0.1261	0.0011
28		1	1	0.8209	0.0817	0.0306	0.0657	0.0010
29		1	1	0.8434	0.0717	0.0288	0.0551	0.0010
30		1	1	0.8353	0.0707	0.0358	0.0572	0.0010
31		1	1	0.8919	0.0244	0.0330	0.0497	0.0010
32		1	1	0.9225	0.0120	0.0276	0.0368	0.0010
33		1	1	0.9234	0.0094	0.0289	0.0373	0.0010
34		1	1	0.9379	0.0067	0.0251	0.0294	0.0010
35		1	1	0.8928	0.0044	0.0501	0.0517	0.0010

36	1	1	0.9729	0.0011	0.0172	0.0078	0.0010
37	1	1	0.9616	0.0010	0.0207	0.0157	0.0010
38	1	1	0.9632	0.0010	0.0196	0.0153	0.0010
39	1	1	0.9661	0.0010	0.0182	0.0138	0.0010
40	1	1	0.9756	0.0010	0.0143	0.0081	0.0010
41	1	1	0.9833	0.0010	0.0102	0.0045	0.0010
42	1	1	0.9784	0.0017	0.0118	0.0070	0.0010
43	1	1	0.9845	0.0018	0.0079	0.0048	0.0010
44	1	1	0.9848	0.0010	0.0067	0.0063	0.0012
45	1	1	0.9656	0.0010	0.0190	0.0134	0.0010
46	1	1	0.9743	0.0010	0.0133	0.0105	0.0010
47	1	1	0.9723	0.0016	0.0160	0.0083	0.0019
48	1	1	0.9788	0.0010	0.0111	0.0077	0.0014
49	1	1	0.9718	0.0010	0.0156	0.0096	0.0020
50	1	1	0.9143	0.0026	0.0409	0.0399	0.0024
51	1	1	0.9135	0.0015	0.0527	0.0295	0.0028
52	1	1	0.9528	0.0010	0.0279	0.0169	0.0015
53	1	1	0.9802	0.0010	0.0133	0.0045	0.0011
54	1	1	0.9837	0.0010	0.0110	0.0032	0.0010
55	1	1	0.9727	0.0020	0.0203	0.0027	0.0023
56	1	1	0.9576	0.0032	0.0330	0.0023	0.0039
57	1	1	0.9737	0.0011	0.0200	0.0022	0.0029
58	1	1	0.9669	0.0010	0.0259	0.0024	0.0039
59	1	1	0.9764	0.0010	0.0180	0.0016	0.0030
60	1	1	0.9687	0.0011	0.0266	0.0012	0.0024
61	1	1	0.9709	0.0013	0.0232	0.0010	0.0036
62	1	1	0.9769	0.0010	0.0192	0.0010	0.0020
63	1	1	0.9739	0.0010	0.0217	0.0010	0.0024
64	1	1	0.9119	0.0093	0.0735	0.0028	0.0025
65	1	1	0.8546	0.0070	0.1285	0.0079	0.0020
66	3	3	0.1473	0.1622	0.6512	0.0381	0.0013
67	3	3	0.0010	0.2396	0.6076	0.1509	0.0010
68	2	2	0.0010	0.6445	0.0945	0.2591	0.0010
69	2	2	0.0010	0.8671	0.0128	0.1181	0.0010
70	2	2	0.0010	0.8248	0.0020	0.1712	0.0010
71	2	2	0.0010	0.9406	0.0010	0.0564	0.0010
72	2	2	0.0010	0.7637	0.0010	0.2333	0.0010
73	2	2	0.0010	0.9177	0.0010	0.0793	0.0010
74	2	2	0.0010	0.9960	0.0010	0.0010	0.0010
75	2	2	0.0010	0.9959	0.0011	0.0010	0.0010
76	2	2	0.0015	0.9946	0.0014	0.0012	0.0013

77		2	2	0.0017	0.9926	0.0010	0.0026	0.0021
78		2	2	0.0017	0.9919	0.0010	0.0033	0.0022
79		2	2	0.0015	0.9924	0.0010	0.0034	0.0017
80		2	2	0.0012	0.9934	0.0010	0.0033	0.0012
81		2	2	0.0017	0.9900	0.0010	0.0058	0.0015
82		2	2	0.0018	0.9886	0.0011	0.0069	0.0016
83		2	2	0.0032	0.9811	0.0018	0.0112	0.0027
84		2	2	0.0039	0.9762	0.0017	0.0153	0.0028
85		2	2	0.0055	0.9714	0.0020	0.0186	0.0026
86		2	2	0.0212	0.9265	0.0086	0.0286	0.0151
87		2	2	0.0560	0.8127	0.0197	0.0771	0.0346
88		2	2	0.0505	0.8238	0.0205	0.0677	0.0376
89		2	2	0.0463	0.8367	0.0273	0.0496	0.0401
90		2	2	0.0484	0.8355	0.0232	0.0478	0.0451
91		2	2	0.0409	0.8450	0.0176	0.0463	0.0501
92		2	2	0.0531	0.8334	0.0162	0.0490	0.0484
93		2	2	0.0670	0.8131	0.0186	0.0507	0.0506
94		2	2	0.0706	0.3860	0.0200	0.3697	0.1537
95	75	2	4	0.1128	0.2478	0.0275	0.4670	0.1449
96	75	2	4	0.2019	0.2431	0.0447	0.3299	0.1804
97	70	1	4	0.2585	0.2108	0.0509	0.2776	0.2023
98		1	1	0.3331	0.1561	0.0543	0.2630	0.1935
99		1	1	0.3822	0.1703	0.0528	0.2070	0.1878
100		1	1	0.4754	0.0932	0.0558	0.2103	0.1653
101		1	1	0.5630	0.0496	0.0425	0.2292	0.1156
102		1	1	0.5609	0.0503	0.0388	0.2459	0.1041
103		4	4	0.0258	0.1840	0.0055	0.7532	0.0315
104	75	2	4	0.0747	0.2561	0.0168	0.5853	0.0671
105		4	4	0.0666	0.2206	0.0184	0.6319	0.0624
106	75	2	4	0.1113	0.2496	0.0188	0.5528	0.0674
107		4	4	0.1072	0.1562	0.0221	0.6740	0.0405
108		4	4	0.1116	0.1117	0.0250	0.7129	0.0388
109		4	4	0.1175	0.0987	0.0255	0.7208	0.0376
110		4	4	0.1249	0.0759	0.0184	0.7320	0.0488
111		4	4	0.1285	0.0424	0.0180	0.7800	0.0312
112		4	4	0.1019	0.0267	0.0173	0.8254	0.0287
113		4	4	0.2038	0.0153	0.0229	0.7074	0.0505
114		4	4	0.2312	0.0110	0.0218	0.6874	0.0487
115		4	4	0.1102	0.0032	0.0125	0.8353	0.0387
116		4	4	0.0658	0.0032	0.0096	0.8962	0.0253
117		4	4	0.0343	0.0018	0.0084	0.9452	0.0104

118	4	4	0.0020	0.0096	0.0043	0.9830	0.0010
119	4	4	0.0036	0.0168	0.0095	0.9686	0.0014
120	4	4	0.0016	0.0164	0.0082	0.9727	0.0011
121	4	4	0.0010	0.0175	0.0062	0.9744	0.0010
122	4	4	0.0010	0.0112	0.0060	0.9808	0.0010
123	4	4	0.0016	0.0216	0.0086	0.9668	0.0013
124	4	4	0.0013	0.0242	0.0130	0.9597	0.0017
125	4	4	0.0010	0.0143	0.0119	0.9718	0.0010
126	4	4	0.0010	0.0142	0.0103	0.9735	0.0010
127	4	4	0.0022	0.0056	0.0109	0.9799	0.0014
128	4	4	0.0010	0.0025	0.0212	0.9743	0.0010
129	4	4	0.0010	0.0023	0.0180	0.9778	0.0010
130	4	4	0.0010	0.0015	0.0152	0.9813	0.0010
131	4	4	0.0010	0.0012	0.0171	0.9797	0.0010
132	4	4	0.0012	0.0010	0.0197	0.9762	0.0019
133	4	4	0.0011	0.0010	0.0161	0.9806	0.0011
134	4	4	0.0010	0.0010	0.0178	0.9792	0.0010
135	4	4	0.0010	0.0010	0.0155	0.9815	0.0010
136	4	4	0.0010	0.0010	0.0148	0.9819	0.0012
137	4	4	0.0012	0.0010	0.0121	0.9846	0.0012
138	4	4	0.0011	0.0010	0.0116	0.9850	0.0013
139	4	4	0.0013	0.0013	0.0121	0.9837	0.0016
140	4	4	0.0010	0.0015	0.0140	0.9815	0.0020
141	4	4	0.0022	0.0029	0.0223	0.9680	0.0046
142	4	4	0.0010	0.0069	0.0519	0.9392	0.0010
143	4	4	0.0010	0.0118	0.0323	0.9539	0.0010
144	4	4	0.0010	0.0077	0.0045	0.9858	0.0010
145	4	4	0.0010	0.0044	0.0017	0.9919	0.0010
146	4	4	0.0010	0.0039	0.0010	0.9931	0.0010
147	4	4	0.0010	0.0024	0.0010	0.9946	0.0010
148	4	4	0.0010	0.0018	0.0010	0.9952	0.0010
149	4	4	0.0010	0.0017	0.0010	0.9954	0.0010
150	4	4	0.0010	0.0010	0.0010	0.9960	0.0010
151	4	4	0.0010	0.0010	0.0012	0.9958	0.0010
152	4	4	0.0010	0.0010	0.0023	0.9947	0.0010
153	4	4	0.0010	0.0010	0.0025	0.9945	0.0010
154	4	4	0.0010	0.0011	0.0034	0.9935	0.0010
155	4	4	0.0010	0.0022	0.0044	0.9914	0.0010
156	4	4	0.0010	0.0010	0.0080	0.9890	0.0010
157	4	4	0.0010	0.0022	0.0112	0.9847	0.0010
158	4	4	0.0010	0.0029	0.0246	0.9705	0.0010

159	4	4	0.0010	0.0039	0.0309	0.9632	0.0010
160	4	4	0.0010	0.0010	0.0189	0.9781	0.0010
161	4	4	0.0010	0.0010	0.0177	0.9793	0.0010
162	4	4	0.0398	0.0010	0.0017	0.9371	0.0204
163	4	4	0.0124	0.0010	0.0020	0.9757	0.0088
164	4	4	0.0076	0.0013	0.0083	0.9796	0.0032
165	4	4	0.0010	0.0010	0.0100	0.9870	0.0010
166	4	4	0.0010	0.0010	0.0099	0.9871	0.0010
167	4	4	0.0010	0.0010	0.0082	0.9888	0.0010
168	4	4	0.0024	0.0010	0.0123	0.9823	0.0020
169	4	4	0.0030	0.0010	0.0131	0.9806	0.0022
170	4	4	0.0036	0.0010	0.0156	0.9774	0.0023
171	4	4	0.0010	0.0044	0.0047	0.9889	0.0010
172	4	4	0.0028	0.0086	0.0053	0.9807	0.0026
173	4	4	0.0049	0.0069	0.0053	0.9792	0.0037
174	4	4	0.0076	0.0065	0.0040	0.9766	0.0053
175	4	4	0.0086	0.0058	0.0043	0.9749	0.0064
176	4	4	0.0128	0.0035	0.0038	0.9714	0.0084
177	4	4	0.0111	0.0032	0.0032	0.9753	0.0072
178	4	4	0.0118	0.0029	0.0031	0.9760	0.0062
179	4	4	0.0165	0.0020	0.0038	0.9703	0.0075
180	4	4	0.0564	0.0088	0.0086	0.9026	0.0237
181	4	4	0.0914	0.0091	0.0100	0.8546	0.0350
182	4	4	0.0882	0.0042	0.0100	0.8744	0.0233
183	4	4	0.0699	0.0051	0.0113	0.8938	0.0198
184	4	4	0.0711	0.0023	0.0116	0.8950	0.0201
185	4	4	0.0420	0.0019	0.0108	0.9276	0.0177
186	4	4	0.0123	0.0044	0.0056	0.9698	0.0079
187	4	4	0.0330	0.0049	0.0124	0.9342	0.0156
188	4	4	0.0271	0.0053	0.0127	0.9446	0.0103
189	4	4	0.0059	0.0015	0.0067	0.9838	0.0020
190	4	4	0.0098	0.0010	0.0104	0.9755	0.0034
191	4	4	0.0272	0.0011	0.0145	0.9496	0.0075
192	4	4	0.0326	0.0025	0.0277	0.9212	0.0161
193	4	4	0.0184	0.0028	0.0376	0.9253	0.0159
194	4	4	0.0197	0.0022	0.0384	0.9302	0.0095
195	4	4	0.0358	0.0010	0.0470	0.9035	0.0127
196	4	4	0.0323	0.0010	0.0657	0.8819	0.0192
197	4	4	0.0867	0.0014	0.1242	0.7659	0.0218
198	4	4	0.1141	0.0012	0.1103	0.7543	0.0200
199	4	4	0.1333	0.0010	0.1140	0.7340	0.0177

200		4	4	0.2108	0.0010	0.1242	0.6330	0.0310
201		4	4	0.2210	0.0010	0.1170	0.6362	0.0248
202	70	1	4	0.2579	0.0011	0.1392	0.5701	0.0317
203	25	1	4	0.3325	0.0010	0.1475	0.4813	0.0376
204	70	1	4	0.3145	0.0010	0.1508	0.5061	0.0277
205	25	1	4	0.3635	0.0010	0.1323	0.4759	0.0273
206		1	1	0.5153	0.0010	0.1372	0.3075	0.0390
207		1	1	0.5818	0.0010	0.1221	0.2460	0.0491
208		1	1	0.6081	0.0010	0.1115	0.2323	0.0471
209		1	1	0.6205	0.0020	0.1036	0.1794	0.0945
210		1	1	0.6577	0.0021	0.1077	0.1008	0.1316
211		1	1	0.7099	0.0020	0.0555	0.1168	0.1158
212		1	1	0.7370	0.0027	0.0527	0.0867	0.1209
213		1	1	0.7758	0.0023	0.0456	0.0635	0.1128
214		1	1	0.8118	0.0018	0.0380	0.0499	0.0986
215		1	1	0.8051	0.0031	0.0409	0.0300	0.1208
216		1	1	0.8094	0.0033	0.0364	0.0138	0.1372
217		1	1	0.8352	0.0016	0.0327	0.0126	0.1179
218		1	1	0.5245	0.0026	0.0388	0.0069	0.4272
219		1	1	0.5894	0.0010	0.0212	0.0076	0.3809
220		1	1	0.6357	0.0010	0.0183	0.0053	0.3397
221		1	1	0.5752	0.0013	0.0134	0.0042	0.4058
222		1	1	0.6182	0.0011	0.0133	0.0037	0.3637
223		1	1	0.5853	0.0012	0.0133	0.0019	0.3984
224		1	1	0.5840	0.0011	0.0094	0.0010	0.4045
225		1	1	0.5818	0.0011	0.0092	0.0010	0.4069
226	65	1	5	0.3445	0.0015	0.0047	0.0010	0.6483
227	65	1	5	0.3395	0.0013	0.0042	0.0010	0.6541
228	25	1	5	0.4016	0.0011	0.0029	0.0010	0.5935
229		1	1	0.5802	0.0010	0.0032	0.0011	0.4145
230		1	1	0.6005	0.0689	0.0052	0.0523	0.2731
231		1	1	0.5457	0.0769	0.0048	0.0351	0.3376
232		1	1	0.5858	0.0668	0.0044	0.0352	0.3077
233		1	1	0.6405	0.0631	0.0024	0.0021	0.2919
234		1	1	0.6870	0.0478	0.0021	0.0012	0.2619
235		1	1	0.6911	0.0451	0.0020	0.0010	0.2608
236		1	1	0.7271	0.0344	0.0018	0.0010	0.2357
237		1	1	0.7449	0.0304	0.0017	0.0010	0.2220
238		1	1	0.7712	0.0186	0.0017	0.0010	0.2075
239		1	1	0.4911	0.3329	0.0012	0.0230	0.1518
240		2	2	0.4177	0.4391	0.0010	0.0231	0.1191

Appendix F. *FORTRAN and C-based Computer Program Listings.*

A copy of the Multiple Model Adaptive Filter FORTRAN program and the C-based SUN Workstation graphics programs are retained at AFIT/ENG, WPAFB, OH.

Appendix G. *KREST Program Listing.*

A copy of the OPS-5 KREST computer program is retained at AFIT/ENG, WPAFB, OH.

Appendix H. *KREST Expert Rules.*

```
;*******************************************************
;
;        Kalman Filter Residual Expert Rules
;
;        (POC - Probability of Correctness)
;
;*******************************************************
;    If the best filter is in the X- or Y-direction and there
;  is significant POC associated with the narrow filter and
;  that POC level is rising, then go with the narrow filter.

;   IF Best=4 or 5 and P1 > 0.3 and
;        P1 is increasing.                      THEN Goto 1

(p Rule25
     (Best ^val << 4 5 >>)
     (P1   ^val > 0.3)
     (P1-Increasing ^val t)
    -(KREST-Best)
-->
     (make KREST-Best ^val  1)
     (make Rule ^val       25)
)

;***********************************************************
;    If the best filter has been the medium maneuver/narrow view
;  view filter for a while and the new best filter is the wide
;  view filter, but the wide view filter's POC level isn't too
;  large and the narrow filter's POC level isn't too small,
;  stick with the medium maneuver/narrow view filter.

;   IF Best=3 for last 3 or more and the
;        new Best=2 and P2 < 0.7 and P3 > 0.2    THEN Stay 3

(p Rule30
     (Last3 ^val 3)
     (Best ^val     2)
     (P2   ^val < 0.7)
     (P3   ^val > 0.2)
    -(KREST-Best)
-->
```

```
     (make KREST-Best ^val  3)
     (make Rule ^val       30)
)
;*************************************************************
;    If there is confusion over whether the X-direction or
;  Y-direction filter can do a better job, and there is
;  sufficient POC associated with the narrow view filter,
;  then go with that narrow view filter.

;   IF P4 > 0.25 and P5 > 0.25 and P1 > 0.18    THEN Goto 1

(p Rule35
     (P4 ^val > 0.25)
     (P5 ^val > 0.25)
     (P1 ^val > 0.18)
    -(KREST-Best)
-->
     (make KREST-Best ^val  1)
     (make Rule ^val       35)
)

;**********************************************************
;    If the medium manuever/narrow view filter is the best,
;  but the no manuever/narrow view filter has a high enough
;  POC level and that POC level is increasing, then go with
;  the no manuever/narrow view filter.

;   IF Best=3 and P1 > (P3 * 0.5) and
;         P1 is increasing.                    THEN Goto 1

(p Rule40
     (Best ^val 3)
     (P1-Is-Greater-Than-Half-Of-P3 ^val t)
     (P1-Increasing                 ^val t)
    -(KREST-Best)
-->
     (make KREST-Best ^val  1)
     (make Rule ^val       40)
)

;********************************************************
;    If the no manuever/narrow view filter has been the
```

```
; best for a while and suddenly the medium manuever/narrow
; view and Y-direction filters have large POC levels, then
; go to the wide view filter.

;   IF Best=1 for last 4 and P3 > 0.2        THEN Goto 2
;      and P5 > 0.4

(p Rule45
     (Last4 ^val    1)
     (P3 ^val    > 0.2)
     (P5 ^val    > 0.4)
    -(KREST-Best)
-->
     (make KREST-Best ^val  2)
     (make Rule ^val       45)
)

;*********************************************************
;    If the no manuever/narrow view filter has been the
; best for a while and suddenly the medium manuever/narrow
; view and X-direction filters have large POC levels, then
; go to the wide view filter.

; IF Best=1 for last 4 and P3 > 0.2          THEN Goto 2
;     and P4 > 0.4

(p Rule50
     (Last4 ^val  1)
     (P3 ^val > 0.2)
     (P4 ^val > 0.4)
    -(KREST-Best)
-->
     (make KREST-Best ^val  2)
     (make Rule ^val       50)
)

;*********************************************************
;    If the best filter has a wide view, but the medium
; manuever/narrow view filter has sufficient POC level
; associated with it, then go to the medium manuever/
; narrow view filter.
```

```
;   IF Best=2 and P3 > 0.25                    THEN Goto 3

(p Rule55
     (Best ^val   2  )
     (P3   ^val > 0.25)
    -(KREST-Best)
-->
     (make KREST-Best ^val  3)
     (make Rule ^val       55)
)


;*********************************************************
;    If the best filter has been the narrow view filter
;   for a while and it still has a sufficient POC level
;   assoicated with it, even if the new best filter is
;   extended in the X- or Y-direction, stick with the
;   narrow view filter.

;   IF Best=1 for last 3 or more and P1 > 0.3
;      and the new Best=4 or 5                    THEN Goto 1

(p Rule65
     (Last3 ^val 1)
     (P1    ^val  > 0.3 )
     (Best ^val << 4 5 >>)
    -(KREST-Best)
-->
     (make KREST-Best ^val  1)
     (make Rule ^val       65)
)

;*****************************************************
;    If the system is confused about whether the X- or
;   Y-direction filter is better, (and there isn't much
;   POC associated with the medium maneuver/narrow view
;   filter), and the narrow filter is better than the
;   wide view filter, and the narrow filter has a POC
;   level that's large enough, then go with the narrow
;   filter.

;   IF Best=4 or 5 and P4 < 0.6 and
```

```
;      P5 < 0.6 and P3 < 0.2 and
;      P1 > 0.1 and P1 > P2                    THEN Goto 1

(p Rule70
     (Best ^val << 4 5 >>)
     (P4   ^val < 0.6)
     (P5   ^val < 0.6)
     (P3   ^val < 0.2)
     (P1   ^val > 0.1)
     (P1-Greater-Than-P2 ^val t)
    -(KREST-Best)
-->
     (make KREST-Best ^val  1)
     (make Rule       ^val 70)
)

;*********************************************************
;    If the system is confused about whether the X- or
;  Y-direction filter is better, (and there isn't much POC
;  associated with the medium maneuver/narrow view filter),
;  and the wide view filter is better than the narrow filter,
;  and the wide view filter has a POC level that is large
;  enough, then go with the wide view filter.

;   IF Best=4 or 5 and P4 < 0.6 and
;      P5 < 0.6 and P3 < 0.2 and
;      P2 > 0.1 and P2 > P1                    THEN Goto 2

(p Rule75
     (Best ^val << 4 5 >>)
     (P4   ^val < 0.6)
     (P5   ^val < 0.6)
     (P3   ^val < 0.2)
     (P2   ^val > 0.1)
     (P1-Greater-Than-P2 ^val nil)
    -(KREST-Best)
-->
     (make KREST-Best ^val  2)
     (make Rule       ^val 75)
)
;*********************************************************
```

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SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1a REPORT SECURITY CLASSIFICATION: UNCLASSIFIED

1b RESTRICTIVE MARKINGS:

2a. SECURITY CLASSIFICATION AUTHORITY:

2b DECLASSIFICATION / DOWNGRADING SCHEDULE:

3 DISTRIBUTION / AVAILABILITY OF REPORT: Approved for public release; distribution unlimited.

4 PERFORMING ORGANIZATION REPORT NUMBER(S): AFIT/GCE/ENG/87D-4

5 MONITORING ORGANIZATION REPORT NUMBER(S):

6a NAME OF PERFORMING ORGANIZATION: School of Engineering

6b OFFICE SYMBOL (If applicable): AFIT/ENG

7a NAME OF MONITORING ORGANIZATION:

6c. ADDRESS (City, State, and ZIP Code): Air Force Institute of Technology
Wright-Patterson AFB OH 45433-6583

7b ADDRESS (City, State, and ZIP Code):

8a. NAME OF FUNDING / SPONSORING ORGANIZATION: Flight Dynamics Lab

8b OFFICE SYMBOL (If applicable): AFWAL/FIGL

9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER:

8c. ADDRESS (City, State, and ZIP Code): Flight Dynamics Laboratory
Air Force Wright Aeronautical Labs
Wright-Patterson AFB OH 45433

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO	WORK UNIT ACCESSION NO

11. TITLE (Include Security Classification): See Box 19.

12. PERSONAL AUTHOR(S): Jeffrey D. Grimshaw, B.S., Captain, USAF

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
MS Thesis	FROM ______ TO ______	1987 December	190

16. SUPPLEMENTARY NOTATION:

17. COSATI CODES

FIELD	GROUP	SUB-GROUP
12	09	
20	03	

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number): Kalman Filter, Residual, Expert System, Knowledge-based System, Sensor Fusion,

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Title: KALMAN FILTER RESIDUAL EXPERT SYSTEM

Thesis Chairman: Elton P. Amburn, Major, USAF
Instructor of Computer Systems

Approved for public release: IAW AFR 190-1
Lynn E. Wolaver 14 Mar 88
Dean for Research and Professional Development
Air Force Institute of Technology (AU)
Wright-Patterson AFB OH 45433

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL: Elton P. Amburn, Major, USAF

22b. TELEPHONE (Include Area Code): (513) 255-3576

22c. OFFICE SYMBOL: AFIT/ENG

DD Form 1473, JUN 86 — Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

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Block 18 (continued) Pilot's Associate

Block 19 (continued)

The Pilot's Associate (PA) Program has been initiated to help mitigate the extensive workload of the fighter pilot. To operate effectively, the PA system must have situation awareness: the status of important on-board and off-board systems. This knowledge is gained through sensor systems. The data from these systems must be "fused" together to present the PA with a coherent picture of the internal (on-board) and external (off-board) states. Although many types of information can be extracted from sensor data, this paper emphasizes those parameters that help determine target track. One common technique for fusing sensor data uses Kalman filters. In a multiple model adaptive filter (MMAF) system, the most appropriate Kalman filter is chosen. This filter provides the "best" estimates of the desired states.

An operating MMAF system continually selects which filter to use as the basis for the state estimates. The overall accuracy of the system is closely related to how well the filters are selected. Previous filter selection techniques have proved useful, but limited. To overcome some of these limitations, an expert system, KREST, was developed so that expert rules could be used to select filters. Although no quantitative estimate of improvement is available, the MMAF expert stated that KREST exhibited a potentially significant improvement over the previously used filter selection techniques.

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